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NEW YORK, SEPTEMBER, 1888.

NEW YORK is just now fortunate in having a Mayor whose "eccentricities" are looked at by the politicians with alarm and disgust, but by the people with very hearty approval. One of these "eccentricities" has been the appointment of four new commissioners to take charge of the new Croton Aqueduct, who are, contrary to all precedent, probably four of the best men in the city who could be picked out for that purpose. Their number includes an engineer of national reputation and three well-known citizens, respectively a builder, a lawyer, and a business man, who are actually almost unheard of in city politics, and have been known only on account of their honesty, public spirit, and ability in conducting their own business. Under their charge it is altogether probable that this great engineering work, which is to complete the arrangements for New York's water supply, will be finished as it should be, and that the new Croton Aqueduct will be hereafter a credit to the city instead of becoming, as it threatened to be, a public scandal. A few more officers as "eccentric" as Mayor Hewitt would be welcomed in the public service, not only in New York, but elsewhere.

THE retirement of General James C. Duane as Chief of Engineers, under the age limitation provided by law, again suggests doubt as to the wisdom of such a regulation, especially in the staff departments of the Army, where long experience is of quite as much, if not more, value than ability to perform active service in the field. In this case General Duane is retired while at the height of his usefulness, and while in all human probability there still remains a number of years during which he would be able to do most excellent service. The duties of the Chief of Engineers are, after all, more in the nature of those of a consulting engineer, and he is not called upon to do the hard work or to undergo the exposure to which subordinate members of the corps are occasionally subjected. That General Duane is still capable of doing excellent work is evidenced by the fact that his appointment to a position where he will probably have entire supervision of the completion of the new Croton Aqueduct meets with universal approval.

THE Canadian Pacific is to lose its monopoly of business in Manitoba, and is to meet with active competition there from the Northern Pacific. The provincial authorities have made arrangements with the latter company to operate a line from Winnipeg to the boundary, and it is expected also that a line will be built from Winnipeg westward to Portage-la-Prairie, Qu'Appelle and Brandon, with several branches to be added hereafter. This line will nearly parallel the Canadian Pacific through the most productive portion of its northwestern territory, and it will give the Northern Pacific access to nearly all the settled portion of that country. The Province not only authorizes the building of the road, but will give a subsidy of $5,000 a mile, with certain other advantages. The road will, of course, be built by a corporation organized in Canada, but under the Northern Pacific control. The American company will thus be in a position to retaliate locally in a great measure upon its Canadian rival for the competition on through business, which it has felt pretty severely, and there will be an opportunity for a very lively war.

THE last loan of the Panama Canal Company has proved a partial failure, only $56,000,000 out of $140,000,000 offered having been taken. *L'Economiste Française*, an eminent authority, states that out of the $56,000,000 subscribed, no less than $44,000,000 will be absorbed by the Government deposit required to guarantee the yearly drawings for redemption of loan, and by the immediate requirements of the company for interest, leaving only $12,000,000 available for the immediate continuance of the work, which is a sum altogether insufficient to secure any considerable progress. In the mean time, M. De Lesseps continues to promise the opening of the canal in 1890, in spite of the fact that it is now well known that this would be utterly impossible, even had the company abundance of means at its command. It is evident, indeed, that a crisis is fast approaching, and that a suspension of work, if not a total collapse of the company, is among the probabilities of the immediate future.

THE Russian Government has suspended, for the present, work on the further extension of its Transcaspian line, and is devoting some attention to the improvement of its connections westward. Two or three lines to ports on the Caspian Sea are now under examination, and the work of construction of one of them has already been begun, while a considerable amount is to be expended in and about the port which is the western terminus of the Transcaspian road itself. The eastward extension of the line has not, however, been abandoned by any means, and the work of building toward the Chinese frontier will be resumed in a few months.

AT the recent general meeting of the Metropolitan Railway Company in London, the President, Sir E. W. Watkin, announced that arrangements were in progress for testing an electric motor on one section of the line. This motor was to be prepared and put in operation by the

Electric Traction Company, which has already some of its engines running on one of the London street railroads. The conditions imposed by the Metropolitan Company are that the electric motor should work as economically, and should, speaking mechanically, have as long a life as an ordinary locomotive. It is expected that the test will begin in September.

The Metropolitan Company probably has a greater interest in this question of electric traction than any other railroad company in the world, as the proper ventilation of the underground line, and the disposition to be made of the steam and smoke from its locomotives, has been the most difficult matter it has had to contend with. The adoption of the electric motor would make the ventilation of the tunnels a comparatively easy matter, and the railroad would then be much more desirable for travelers.

AS finally agreed on in conference between the Senate and the House, the Army Bill appropriates $700,000 for the equipment of the gun factory at the Watervliet Arsenal and $3,500,000 (instead of $5,000,000) for the purchase of steel forgings for guns. The expenditures, both for the forgings and for the gun factory, are to be made under the supervision of a board, which is to consist of the Chief of Ordnance, the Chief of Engineers, and an artillery officer to be designated by the Secretary of War.

IT is understood that the Bureau of Construction in the Navy Department has under preparation plans for two vessels to be built under the appropriation for coast and harbor defense. These plans are not yet ready to be made public, but it is said that the ships are to be of the single-turreted *Monitor* type, of about 3,500 tons displacement, and are to carry in the turret one 16-in. gun, with one or two dynamite guns of large size mounted in the hold or under the decks. They are to have engines of the latest pattern, and are to be able to make at least 16 knots per hour. This speed will not have to be kept up for a long distance, as these ships are not intended for cruisers.

The present double-turreted ships of the *Monitor* type, which are now in process of completion, are of about 3,000 tons displacement, and are to be armed with four 10-in. guns (two in each turret), except the *Puritan*, which is to have somewhat heavier guns, and is of 3,900 tons displacement.

A 16-in. gun is a very formidable weapon, and how it will work on a comparatively light ship is not altogether certain. This gun and the two dynamite guns ought to make these ships dangerous antagonists to any vessel now afloat, and effective assistants to land defenses.

The design of these ships is original, and they will doubtless be sharply criticised by naval authorities. The publication of the plans will be looked for with much interest.

AN example of the steamboat business done on the Upper Hudson—and of what might be done on the Lower Hudson with proper management—may be found in the fact that on Saturday, August 4, the *Mary Powell* carried 1,600 passengers on her afternoon trip up from New York. This was no special excursion, but only the regular trip which this boat makes, landing at half a dozen points along the river from West Point to Rondout.

HOW TO BECOME AN ENGINEER.

THERE are probably few engineers who do not from time to time receive letters somewhat like the following:

> I have a son eighteen years of age who is anxious to obtain employment with some reliable person to study or learn the art of Civil Engineering. He is a smart, intelligent boy, and with proper training I think something could be made of him. I would esteem it a great favor if you could take him in hand, or perhaps you could introduce him to some parties in this section who would do so.

Those who have passed the half century meridian of life, where hopefulness begins to decline, probably finish reading such letters with a sympathetic sigh for the young aspirant who has the struggle, the weariness, and the disappointments of life still before him, and who, like all young people happily, has only a faint idea of the difficulties which stand in the way of success. Unfortunately, too, human beings, especially young ones, have only a limited capacity for profiting by the experience of others. Perhaps that, too, is as it should be, because characters are so unlike that the experience which would indicate to one person one course of action might lead another in quite a different direction.

About all that can be done, then, when those who are inexperienced ask for help, is to turn them so that they will face in the right direction, and then leave them to make their own careers, as all of us must do eventually at any rate.

Perhaps the first thing which needs to be said in reply to a letter like the one which has been quoted, is that the terms "Engineer" or "Civil Engineer" are very indefinite, and evidently the correspondent quoted has a very vague idea of the profession or occupation which his son wishes to enter. Perhaps the best service which could be rendered to this correspondent would be to mark out with red ink—for emphasis—the words *engineer* and *engineering*, where they occur in his letter, and request him to substitute some other and more definite terms. This might lead him to inquire, and such inquiry would reveal that the terms engineer and engineering are generic, and include a great variety of occupations which demand an almost equal diversity of qualifications for their successful conduct. The term *engineer* is not more definite than "merchant" is. If some one had written to our correspondent that he had a son who was anxious to become a merchant, the natural question would be, What does the young man want to sell? It is just as essential, before a person engages in the occupation of an engineer, that he should know what he will make, as it would be if he entered mercantile life that he should determine what he will sell.

But, unfortunately, mankind—and more especially womankind—have a great propensity to euphemism—that is, to disguising common things with fine names. There is an enterprising dealer in fish in New York who announces himself as an importer of "sea food." Another firm announce that they are dealers in "Products of the Levant, Orient and Mediterranean." Just what the latter have for sale we have no means of knowing, but raisins, rugs, and rags are products of the regions named, and perhaps are included in the articles they buy and sell. Now, not many young men who think they are entitled to social distinction—or their mothers either—would like to announce that they or their sons had gone into the old rag business, although

they might be quite willing to have it announced that they had accepted a position in the office of a firm who are importers of the "products of the Orient." In the same way the euphemism of the term "engineer," and especially "civil engineer," attracts many young persons to the various occupations to which those fine-sounding terms are applied. As a matter of fact, the occupation or the "profession"—if it is regarded as such—of a "civil engineer," as it was practised fifty years ago, has, by processes of integration and differentiation, almost ceased to exist. Then a civil engineer was a person whose scientific training and experience was supposed to qualify him to undertake the construction of any structure or mechanism required. He located railroads and canals, superintended their construction, designed the bridges and machinery, and had charge of all the construction on the line. Now everything has become specialized. The location is intrusted to one man, and he or his class, more than any others, seem to have clung to the title of "civil engineer" up to the present time. Few locating engineers, however, now design bridges. Wooden, metal, and stone bridges are each specialties, and the persons who undertake the construction of one kind seldom take up any other. The same is true of turn-tables, water-supply structures, switches, signals, stations, locomotives, cars, etc., etc. Not only is this the case, but the different parts of cars and locomotives have become specialties. Wheels, springs, axles, brakes, car-seats, ventilators, injectors, lubricators, headlights, steam gauges, safety-valves, and many other parts are made by firms and companies which devote their time and attention exclusively to their manufacture.

The same thing is true of all branches of engineering. In marine work, stationary engines, electrical machinery, tools, agricultural implements, and so on indefinitely, the occupations of those who make these structures is daily and yearly becoming more and more specialized. There are, it is true, some men still needed to locate railroads, to construct water-works, docks, and improve our water-ways, but these occupations are also becoming specialties.

It is, therefore, of the utmost importance that when a young man or his parents determine that he should become an "engineer" that they, or he, should have some clear idea of what he proposes to do. First, though, let him banish from his vocabulary the indefinite term "engineer," and then select some specialty from the many occupations open to him. The field is almost unlimited. He can become a bridge-builder, but he must make up his mind whether he will build them of metal, of wood, or of stone. He might make water-closets and call himself a "sanitary engineer," but the assumption of the title will not change the nature of his occupation. It should be impressed on his mind though that to be successful he must enter and confine himself to some narrow field, and that the principles which would command success if he were a maker of mouse-traps or a vendor of cheese will have a great deal to do with his success even if he gives himself the fine title of "engineer."

To young men who want to be engineers, and to their parents, it should be said that there is usually nothing very grand about the occupation. Success in it is governed by very much the same considerations as control other kinds of business. The thing to be aimed at is to learn how to do some one thing as well or better than any one else can do it. If a person goes into the manufacture of steam-engines, he must make as good or better engines than other makers are producing, or he will lose his trade. If he seeks employment he will soon find that what people are willing to pay for is special, not general knowledge—that is, individuals, firms, and companies hire employés for their ability to do some special thing well. A railroad company will hire an engineer because he knows how to locate a railroad or maintain it as well as any one else could, but is probably indifferent to his other qualifications. A draftsman is employed because he knows how to draw and design some special kind of structure. A foreman of works is hired because he understands the practical work of the shop, and has the needed energy and skill to get out work.

The question as to the preparatory training which will best qualify a person for an engineering occupation is one which has been much discussed of late. It may be said, without hesitation, that very little scientific education is absolutely essential to make a successful engineer. This is proved by the fact that a very large proportion of those who have succeeded in this country and in Europe have had only a very limited scientific education. But this is like saying that a good workman can do a good job with poor tools. The need of a higher degree of technical training is each year becoming more essential. It is undoubtedly true that a young man who begins his career with a good education has now a very great advantage over one who starts without such an equipment. But it should be remembered that students cannot be taught how to practise a profession in a school. What seems to be an error in the teaching of technical schools of the present day is a disposition to try to teach a trade or profession. As Sir William Armstrong, in an article reprinted on another page, very truly says, "A man's success in life depends incomparably more upon his capacities for useful action than upon his acquirements in knowledge, and the education of the young should, therefore, be directed to the development of faculties and valuable qualities rather than to the acquisition of knowledge, which may be deferred to more mature age;" or as an experienced educator has expressed it, "Mental growth consists largely in the power to abstract the mind from the things of sense, and to handle the thought when not clothed in matter." Education should bear the same relation to the mind that gymnastics do to the body. In a gymnasium the exercises are not selected for any other use excepting that of exercising the body. So in a school, studies should be chosen with a view chiefly to the exercise and training of the mind. It is not of any very great importance how the mind has been trained, but it is important to persons who now engage in any branch of engineering that they should be able to comprehend, analyze, and investigate the subjects which every year become more abstruse and require a higher degree of mental culture to understand.

NEW PUBLICATIONS.

AN INDEX TO ENGINEERING PERIODICALS, 1883 TO 1887, INCLUSIVE. COMPRISING ENGINEERING; RAILROADS; SCIENCE; MANUFACTURES AND TRADE: BY FRANCIS E. GALLOUPE, M.E. Boston; published by the Author (price, $2).

Mr. Galloupe presents in this volume an index which is evidently the result of much patient labor, and which must

be an exceedingly useful labor-saving book to all engineers who use it. So much of the best engineering literature is now published in the various periodicals that complete books on any technical subject are growing more difficult to find; and the engineer who would keep up with the progress made in his branch of the profession must be a student of the magazines and papers. But some of these are not well indexed, and even with those which do provide their readers with this necessity, it would be impossible always to remember in which one an article was published, so that a long search through a number of indices would be required to find it.

Mr. Galloupe has undertaken to help the busy reader by supplying a general index covering 19 of the leading engineering periodicals, American and English. His index is carefully arranged by subjects, and contains over 10,000 references. With this the searcher cannot only find any special article which he wants, but can also readily get at what has been published on any special subject.

The utility of this volume will be apparent to every one, and it is to be hoped that it will have the extended sale which it deserves. It may be safely said that no one who has once had occasion to use it will be willing to give it up.

We understand that Mr. Galloupe hopes hereafter to extend his work, making it cover additional years, and take in also the *Proceedings* of the various engineering societies. This will be a good work, and one deserving all possible encouragement.

The book is published in very neat form. The references are plain, and the arrangement by subjects a very good one.

REPORT OF THE PROCEEDINGS OF THE TWENTY-FIRST ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

This report has been issued very promptly this year, and has made its appearance within two months after the meeting was held. It is of about the usual size and character, and shows the Association to be in a prosperous condition. The membership has increased from 277 last year to 322 this. The committee reports are perhaps somewhat less interesting than usual, but as the Association has been receiving, and the members writing, reports on locomotives for twenty-one years, it is perhaps not remarkable that it becomes difficult to say anything new or interesting on these subjects. Still, if the members depended less on the opinions of their colleagues in making their reports, and more upon their own observations and study, perhaps what they write would be newer, more interesting and valuable than it now is. If, for example, any of the members who have the care of a considerable number of locomotives would keep a careful record of all their breakages and failures on his road during one or more years, and should give an accurate and specific report and description of each, with drawings showing the character of the breakages, when such drawings are needed, it would form a valuable contribution to our knowledge of locomotive performance. Careful and accurate notes of the effects of corrosion on all the locomotive boilers of a line on which the water is bad would also be useful. A locomotive superintendent or master mechanic has under his eyes daily a series of object lessons from which much more interesting reports could be made than it is at all likely he can evolve by any process of scientific deduction.

During one of the meetings there was some discussion of the benefit to the Association of its associate members, in which there was a flavor of animadversion for which there may be good reason. But it should be observed that as such members occupy the relation of guests to the Association, they are therefore not in a position to take a very active part in the proceedings; and to assume that "personal gain" is the only motive which leads persons to become associate members is putting a low estimate on those motives. The fact is, it is a great honor for the Association, by an almost unanimous vote—and it must be nearly unanimous to elect an associate member now—to say to a person—as it does say when an associate member is elected—"We think that you have such a knowledge of science or such practical experience in matters pertaining to the construction of rolling stock as would be of *especial* value to us or to railroad companies," and therefore you have been elected an associate member. Such an election should be regarded by both parties as an honor, and not as a license for axe-grinding, for which the Association is expected to supply the motive power.

SPECIAL TOOLS FOR RAILWAY REPAIR SHOPS. Philadelphia; Pedrick & Ayer, 1025 Hamilton Street.

This firm have just issued a new edition of their descriptive catalogue, which is very neatly printed with tinted margins and very good engravings of the tools and machines they make. These are milling machines, with chucks, index heads, and other attachments, cylinder boring and facing machines, universal tool-grinding machines, apparatus for heating, setting, and removing tires, and its application to heating and straightening boiler plates, valve-seat rotary planing machines, portable valve chucks, portable cylinder boring machines, crank-pin machines, Greenwood's planer chucks, steam chest seat milling machines, wrist-pin machines, flue-cleaning machines, planer tools, jointer for facing brasses, link-grinding machines, radius link planers, portable drilling machines, cylinder planing chucks, mandrels for turning eccentrics, shrinkage gauges, boiler tube cutters, car-wheel circumference measures, portable key-seating machines, portable bench vises, portable hand drills, extension jacks, the "Gyp" engines, etc.

It is a very excellent example of this kind of literature with full and lucid descriptions of the machines which are illustrated, in which such publications are often lacking.

ABOUT BOOKS AND PERIODICALS.

AN article of especial interest appears in the August number of NEW YORK RAILROAD MEN, entitled "Why Railroads are Made," by Walter Katte. The Author discovered that a much wider field was opened for him to cover than he had any idea of at the outset, but his experience on this subject enables him to do it justice.

In SCRIBNER'S MAGAZINE for August, the fourth article on the Railway Series is contributed by General Horace Porter, on Railway Passenger Travel. General Porter has the faculty of bringing out the most interesting and striking features of the subject. He also touches upon the questions of car-couplers, steam-heating switches, checks, immigrant transportation, and the ratio of accidents.

A very interesting chapter in the early history of ironclads appears in the August CENTURY, where the story of

the Confederate cruiser *Albemarle* is told by the officer who designed and superintended her construction, and by several of those who tested her fighting powers. The *Albemarle* was necessarily an experiment, and was built under many difficulties, but was nevertheless a fighting ship with considerable power of resistance. The attempt of the wooden ship *Sassacus* to sink or disable the *Albemarle* by ramming was one of the boldest exploits in our naval history. The CENTURY gives a history of the ship from her first building to her destruction by a torpedo. Perhaps the thing which strikes one most in reading this article is the very small advance which has really been made in the 24 years since the *Albemarle* ran her brief course. Our modern ships have been improved in detail, but are hardly any better fighting machines, after all, and there has never been a better instance of the use of the torpedo than when Lieutenant Cushing fixed one under the *Albemarle* in the Roanoke River.

THE CARS IN PROPHECY AND HISTORY is an extraordinary book, in which the Author, Rev. D. T. Taylor, present proofs (?) of the nearing end of the age. The Author says, " A railway train moving but a mile a minute dashes over the ground 88 ft. every second. This is literally to dart or shoot. Ancient travel was at a snail's pace compared with the speed of the man whose hand controls the engine. This is the chariot of fire! Settle in your hearts then, reader, that here is a Divine prediction made 2,500 years ago in Asiatic lands of the coming of an extraordinary age of travel, travel in great haste; and this infers new methods, new facilities, and new powers at the command of man. Are such methods in use? Then the prediction is accomplished, the consummation near." Again, " The discovery of the practical use of steam and electricity was reserved for these closing days of this world's history, when the king's business would require haste." The book reads like the work of one who is sincere, but so chimerical as to be hovering on the border between sanity and insanity.

BOOKS RECEIVED.

ANNUAL ACCOUNTS AND STATEMENTS OF THE COMMISSIONERS OF SEWERAGE AND WATER SUPPLY FOR THE CITY OF ST. JOHN (EAST SIDE) AND TOWN OF PORTLAND: GILBERT MURDOCH, C.E., ENGINEER AND SUPERINTENDENT. St. John, N.B.; published for the City.

PROCEEDINGS OF THE INDIANA SOCIETY OF CIVIL ENGINEERS AND SURVEYORS AT THE EIGHTH ANNUAL MEETING, HELD IN INDIANAPOLIS, JANUARY 17, 18 AND 19, 1888. Indianapolis, Ind.; issued by the Society.

AMERICAN INSTITUTE OF ARCHITECTS: PROCEEDINGS OF THE TWENTY-FIRST ANNUAL CONVENTION, HELD IN CHICAGO, OCTOBER 19, 20 AND 21, 1887. E. H. KENDALL AND A. J. BLOOR, EDITORS. New York; published by the Institute.

HEATING PASSENGER CARS BY STEAM FROM THE LOCOMOTIVE: REPORT OF PROFESSOR GAETANO LANZA. Boston; published by the Massachusetts Institute of Technology.

DRY STEAM THE FOUNDATION OF ECONOMY. New York; published by the Stratton Separator Company.

THE PROPOSED CHANGE OF PLAN IN THE EXECUTION OF RIVER AND HARBOR IMPROVEMENTS: THE ORGANIZATION OF A CIVIL BUREAU OF HARBORS AND WATERWAYS. This is a reprint of the arguments presented before the Congressional committees on the Cullom-Breckenridge bill by a committee of the Engineers' Club of St. Louis.

POCKET HAND-BOOK OF COPPER AND IRON WIRE IN ELECTRIC TRANSMISSION AND THE WORLD'S FACTS OF ELECTRIC SERVICE. Worcester, Mass.; issued by the Washburn & Moen Manufacturing Company. This little book, in addition to the catalogue of sizes and electrical resistances of different kinds of wire, contains in a condensed form a number of useful facts in relation to electricity, including a brief dictionary of electrical terms and an index of current electrical literature.

Running Long Tangents.

To the Editor of the Railroad and Engineering Journal:

CAN you say if bearings in a railroad survey are all taken from some one particular meridian or not? If not, suppose you were running a long east-and-west (or nearly so) tangent, say 100 miles, at its end it would have a different bearing, but still be a straight line; and how often would true meridians be taken and reading of azimuth, as you might say, change? This would be a very interesting point, and among the list of railroad engineering writers not the first one has ever said what is the customary practice on this point.

Larimore, Dak. L. S. CARRUTH.

[In a railroad line 100, 200, or more, miles long the bearings are not taken from any one particular meridian, but are taken by each engineer in reference to the true meridian upon his part of the work.

In running a tangent, say 50 or 100 miles long, the bearings would have very little to do with it, with the exception of one running due north and south.

As many prominent points as possible would be established on the proposed tangent by means of triangulation or trial, or, as is often the case in a country where a long tangent is possible, some prominent, permanent point, such as a mountain-top, church steeple, etc., is taken as a fore-sight.

However the points are obtained, a long tangent should always be run by fore-sights only, using the back-sights as a check on the adjustment of the transit.

The bearing could be taken as often as desired, but it would not be used in the running of the tangent.

In latitude 40° any tangent starting with a due east-and-west bearing will have the bearing changed about 0¾′ in every mile, and as the compass needle reads only to about 15 minutes, a difference would be noticeable only every 15 or 20 miles.

But on all railroad work the great reliance for accuracy is placed in the precision of the transit and angular measurement, not on the bearings of the lines.—C. D. J.]

Gas as a Supplement to Steam in Heating Cars.

To the Editor of The Railroad and Engineering Journal:

HAS the car-heating question become *res adjudicata*? So far as the use of steam from the engine after the cars are in motion is concerned, it undoubtedly is so; but how much further? In other words, are stationary steam boil-

ers and coal furnaces—the means now relied upon for heating cars when steam from the engine is not available—the best that can be used for that purpose?

Judging from appearances, our railroad companies think they are, and therefore, in the absence of proof to the contrary, will naturally act upon that opinion, as the time for fitting up their cars for winter use is now so limited.

The question, therefore, Can such "proof to the contrary" be given? becomes of immediate moment, as we think the following facts and inferences will show, stated here, so far as they relate to steam plants and coal stoves, not because I think they are in any way new, but that they may be considered in close contrast with what is stated afterward.

1. Relating to steam plants. As they answer for no other purpose than to heat the cars for the short time before the engine comes, and even for that inconveniently when several trains are to be heated at the same time, as occurs at terminal points on all trunk lines; and when used as a system must be provided at all stations where trains are made up, and kept always ready for use, however limited it may be; it is evident that nothing but necessity can justify the great cost necessary for their use.

2. Relating to heaters and coal stoves. As it is not pretended they can be used for preliminary heating, as for that use the fuel must be removed from them through their doors after short use, and in a glowing state, before the car leaves the station where the train is made up, they must be kept in the car, if kept at all, for no other use than as a substitute for the engine when it breaks down, and so again nothing but necessity can excuse their use.

3. Assuming, as I think I have proved, that nothing but necessity can justify the use of steam plants and coal heaters as supplements to steam from the engine in heating cars, we come to the question, Does that necessity exist? or rather to the question—If gas can be practically used for the purpose above stated, is it not a better means for it than steam plants and coal stoves? as if it is not there is no other, and if it is, nothing touching the interests of railroad companies is more important for them to know.

We therefore ask their serious attention to the following facts, beginning with an explanation of why gas has not been practically used for heating cars hitherto, before considering why it should be so used hereafter, as, until we remove the prejudice now existing against it for such use, it is useless to go on.

If we examine the apparatus in general use for burning gaseous fuel, we will find that it consists of an open case provided with perforated pipes for burning the gas, but without means for confining the air passing through it to the gas jets, or in any way regulating its flow to what is required for combustion; and that the system upon which the gas is burned in it is what is known as the Bunsen system—*i.e.*, mixing air with the gas previous to burning it in the proportion of 2 to 3 parts air to 1 of gas.

It follows that, as the fuel used in a Bunsen stove is only one-third gas at its ignition point, the heat there generated is not sufficient to maintain continued combustion thereafter, and therefore its products (chiefly carbonic oxide), instead of being burned up, must largely pass off as waste, proved also by the fact that the makers of Bunsen stoves always advise they should never be used without a flue to the chimney to prevent said waste from being breathed—C O being a very poisonous gas. Nor is that all, as, even assuming that the objections to Bunsen stoves are compensated for by their convenience when they are used for small purposes, where the direct impact of flame does the work, and therefore the draft can be kept down, there can be no question that when gas must be burned in quantity and under draught, and heat alone must be relied on (as must be the case in heating cars), its use in the apparatus now in general use for burning gaseous fuel must be attended with still greater waste, as when so used at least one-half of the heat generated is lost from the cold air dilution to which it is exposed in doing its work, as more of the air entering the apparatus passes around and away from its flame than in contact with it.

And it is for these reasons, much more than from defects of constitution so far as manufactured gas is concerned, and, so far as natural gas is concerned, from its being burned from open pipes and therefore at excessive waste,* that gas as a fuel has been so underestimated, speaking not only from our own knowledge, but from the opinions of some of the ablest gas engineers in this country.

Having now cleared the way, I trust, to a fair treatment of the question, Whether gas can be practically used for heating cars? we come to what is required to make it so—to wit, How it must be burned; how it must be used; and what it will cost.

1. How it must be burned.

Having shown how it must *not* be burned, the answer to this question is easy: by using the gas in a pure state (instead of diluted with air 2 to 3 times, as it is in a Bunsen stove) on its issue from the burner, to ensure the highest heat possible at that time; and so construct the furnace that the air used in it for combustion must strike into the gas instead of merely slide over it at its point of ignition, and that no air whatever can pass beyond that point except in contact with flame; so that not only when combustion commences, but thereafter, the furnace will operate with an automatic draft—viz., more or less air as more or less gas is burned, and therefore nothing but undiluted heat can enter its flues. Now contrast this construction and operation with those of the apparatus now in general use for burning gaseous fuel, and you will not be surprised when I state from my own experience that when large amounts of gas are burned the quantity required in the former case, when compared with what is required in the latter, will be as 1 to 3.

2. How it must be used.

Doubtless there may be other answers to this question, but however that may be, the following should be a satisfactory one, as it meets all the conditions required to make it so—to wit: in a furnace which will burn the gas with an automatic draft, so that whether much or little of it is used there will be no material waste of fuel or heat; which can be used without inconvenient or expensive alteration of the cars, and supplied with gas through pipes placed under them and connected between them, as steam pipes now are, so that the gas used can come direct from street mains (to avoid the cost and care of storage tanks and their complicated connections), and when so used all the furnaces in a train can be supplied from one connection with said mains, turned on when the heating commenced and off when the engine came; which is so constructed that it can be changed from a gas to a coal burner or back again

* There must be much improvement in burning natural gas at present, but when I was at Pittsburgh I estimated the amount wasted, as it was burned under boilers then, to be 90 per cent. of the amount used; and yet we find the results from its use quoted, even in scientific journals, as proving gas to be a weak fuel.

in a few minutes, and without other trouble than removing a plate left movable for that purpose, to provide for cases where trains are made up at stations where there is no gas, and for cases where, from the disabling of the engine away from terminal points, the cars would be left without heat if dependent for it upon the engine alone; and finally, which will use the fuel in it, whether gas or coal, indirectly—to wit, through the medium of steam, so that, whether the car is heated by it or from the engine, only one direct heating agent will be used—to wit, steam.

As objections have been made to generating steam on the car, which would require water to be carried in the boiler used, I add that from the short time such steam would be required, viz., about half an hour a day, the small quantity of water used could easily be put into the boiler when the train was made up, and what remained when the engine came could as easily be run out. It should also be added that, while we think the use of steam alone is preferable for the reasons we have stated, the furnace can as well be adapted to heating the cars with warm air, or radiation from its surface and flues, when so preferred; and when it is so used even has some advantages, to wit, less weight and cheaper construction.

3. What it will cost.

(1st) For the apparatus required, not materially over $100 per car when it is constructed as we have described, as but one apparatus is used, and no other alteration of the car required (except for the pipes under it, when it is desired to heat a train from one connection with the gas mains under the track) than to substitute it for the stove at present used.

(2d) For the gas used. There is no question that the time is near when gas will be generally used as fuel, in which case its consumption will be so greatly increased that the price at which it can be sold will be at most, even for carbureted gas, $1 per 1,000 ft., and in large cities much less.

But, waiving that inference, when gas, as now made—from 18 to 25 candle-power—is burned as we have described, the time used by it to heat a car so far as required before the engine comes cannot exceed 25 to 30 minutes, as, when the apparatus used is properly constructed, the steam generated in it should form quite freely in 10 to 12 minutes.

If, then, the gas is burned even at the rate of 60 ft. to 80 ft. per hour, the amount required to heat the car for one trip, however extended it may be, will not average over 35 ft., costing, at even $1.50 per 1,000 ft., 5¼ cents.

But suppose its cost was twice that, would not gas even then be preferable to steam plants and coal stoves, without taking into the account the inconvenience of keeping the latter in the car, if kept at all, as useless weight, except only for the few occasions when the engine breaks down?

It will be observed that we have said nothing in this paper relating to the use of gas for lighting purposes, as to treat that subject properly would require more extended notice than the length of this paper will permit, especially as we would have to take electricity into the discussion.

But we will hazard a single reflection germane to the matter. Taking into the account the cost and complication attending the use of electricity for lighting cars, is there any common-sense in using it for that purpose in preference to gas, when the use of the latter is being daily improved, and its cost will soon be $1 per 1,000 ft. in all large cities, and much less when it is generally used as a fuel, as it soon will be?

HENRY Q. HAWLEY.

The Sun Motor.

(Captain John Ericsson, in *Nature*.)

INDIA, South America, and other countries interested in the employment of sun power for mechanical purposes have watched with great attention the result of recent experiments in France, conducted by M. Tellier, whose plan of actuating motive engines by the direct application of solar heat has been supposed to be more advantageous than the plan adopted by the writer of increasing the intensity of the solar rays by a series of reflecting mirrors. The published statements that "the heat-absorbing surface" of the French apparatus presents an area of 215 square feet to the action of the sun's rays, and that "the work done has been only 43,360 foot-pounds per hour," furnish data proving that Tellier's invention possesses no practical value.

The results of protracted experiments with my sun motors, provided with reflecting mirrors as stated, have established the fact that a surface of 100 square feet presented at right angles to the sun, at noon, in the latitude of New York, during summer, develops a mechanical energy reaching 1,850,000 foot-pounds per hour. The advocates of the French system of dispensing with the "cumbrous mirrors" will do well to compare the said amount with the insignificant mechanical energy represented by 43,460 foot-pounds per hour developed by 215 square feet of surface exposed to the sun by Tellier during his experiments in Paris referred to.

The following brief description will give a clear idea of the nature and arrangement of the reflecting mirrors adopted by the writer for increasing the intensity of the solar heat which imparts expansive force to the medium propelling the working piston of the motive engine. Fig. 1 represents a perspective view of a cylindrical heater, and a frame supporting a series of reflecting mirrors composed of narrow strips of window-glass coated with silver on the under side. The frame consists of a light structure of wrought iron or steel provided with transverse ribs, as shown by the illustration, each rib being accurately bent to a parabolic curvature, whose focus coincides with the axis of the cylindrical heater. It need hardly be stated that the mirrors supported by the said transverse ribs continue from side to side of the frame, which accordingly resembles a parabolic trough whose bottom is composed of mirrors. It will be readily understood that this trough, with its bent ribs and flat mirrors, forms a perfect parabolic reflector, to which a cylindrical heater, as stated, may be attached for generating steam or expanding the gases intended to actuate the piston of the motive engine. Regarding the mechanism for turning the reflector toward the sun, engineers are aware that various combinations, based on the principle of the "universal joint," may be employed.

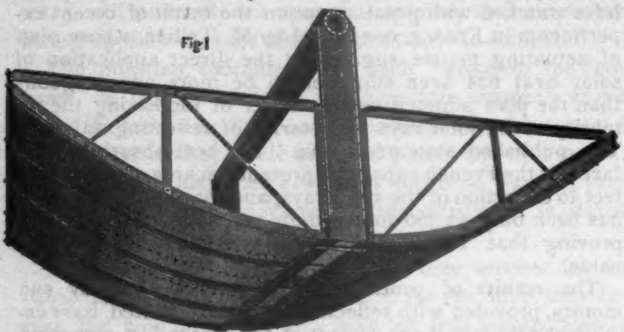
Concerning previous attempts made in France to utilize solar energy for mechanical purposes, it is well known that practical engineers, having critically examined Mouchot's solar engine, which M. Tellier proposes to supersede, find that it is incapable of developing sufficient power for any domestic purpose. Again, the investigations carried out by order of the French Government to ascertain the merits of Mouchot's invention show that, irrespective of the great expense of silver-lined curved metallic reflectors for increasing the insufficient energy of direct solar radiation, these reflectors cannot be made on a sufficient scale for motors having adequate power to meet the demands of commerce; nor is it possible to overcome the difficulty of rapid wear of the delicate silver lining of the metallic reflectors consequent on atmospheric influence, which, after a few hours of exposure, renders their surfaces tarnished and ineffective unless continually polished. A glance at the accompanying illustration (fig. 1) shows that the reflector constructed for my sun motor differs altogether from that originated by Mouchot, which Tellier's apparatus, tested at Paris, was intended to displace.

1. The mirrors which reflect the solar rays are devoid of curvature, being flat narrow strips of ordinary window-glass cut to uniform width and length, perfectly straight.

2. The under sides of said strips are coated with silver by a process which prevents the action of the sun's rays from destroying the silver coating, as in ordinary looking-glasses.

3. The mirrors supported by the bent metallic ribs extending from side to side of the parabolic trough are held down by the heads of small screws tapped into the ribs. Thin slats of wood may be introduced between the mirrors

Fig 1



and the ribs—an expedient of some importance in localities where the reflector is exposed to high winds.

4. It needs no explanation that the *reflecting surface* of the mirrors cannot become tarnished by atmospheric influence, since the bright side of the silver coating is permanently protected by the glass; hence it will be only necessary to remove *dust* from the mirrors, an operation readily

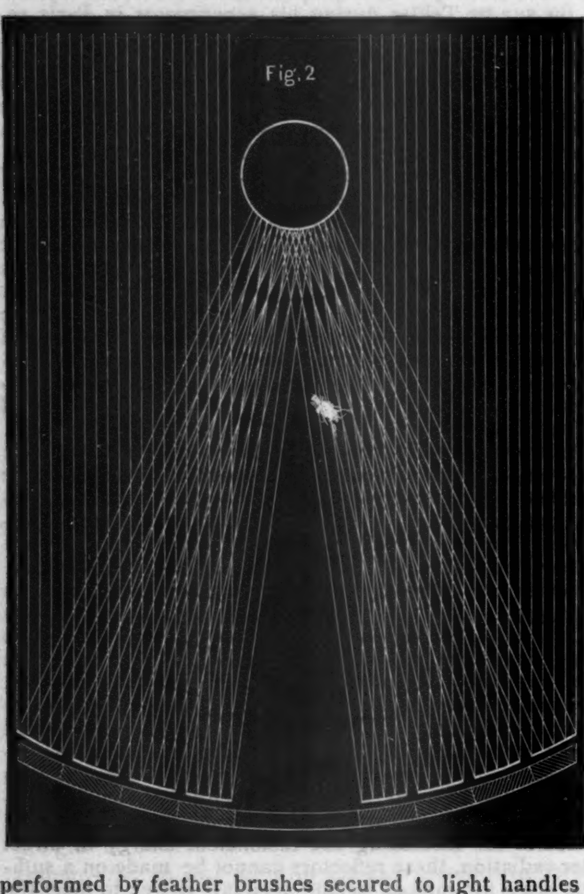


Fig. 2

performed by feather brushes secured to light handles of suitable length.

5. The frame of the reflector, being composed of rolled bars of iron or steel, requires no finish, excepting the top of the transverse ribs, which must correspond accurately with a given parabolic curvature. It should be observed that the needed accuracy is readily attained by a cutting tool guided by a bar of proper form.

6. Regarding cost of construction, it will suffice to state that manufacturers of glass, both in the United States and Germany, supply the mirrors, cut to exact size and silvered, at a rate of 60 cents per square foot, the weight being 106 pounds per 100 square feet. Consequently the cost of the reflector and heater for the sun motor will not much exceed that of a steam boiler and appurtenances, including chimney. The cost of the engine, apart from the reflector, will not be greater than that of an ordinary steam-engine.

7. With reference to durability, it will be evident that the light metallic frame with its mirrors, and a heater acted upon only by reflected solar heat, will last much longer than steam boilers subjected to the action of fire, soot, and corrosion.

Let us now briefly consider the distinguishing feature of the sun motor—namely, the increase of the intensity of the sun's radiant energy by *parallel* rays and *flat* reflecting surfaces permanently protected against atmospheric influence. It has been supposed that the lens and the curved reflecting surface, by converging the sun's rays, could alone increase the intensity of radiant heat. But Newton's demonstration, showing that the temperature produced by solar radiation is "as the density of the rays," taught me to adopt, in place of curved surfaces and converging rays, flat surfaces and parallel rays, as shown by fig. 2, which represents a transverse section of part of the reflector. The direct vertical solar rays, it will be seen, act on the mirrors; while the reflected rays, divided into diagonal clusters of parallel rays, act on the heater, the surface of which will thus be exposed to a dense mass of reflected rays, and consequently raised to a temperature exceeding 600°F. at noon during ordinary sunshine.

The cost, durability, and mechanical energy of the sun motor being thus disposed of, it remains to be shown whether the developed energy is continuous, or whether the power of the engine changes with the increase and diminution of zenith distance and consequent variation of atmospheric absorption. Evidently an accurate knowledge of the diathermancy of the terrestrial atmosphere is indispensable to determine whether the variation of the radiant energy is so great that the development of constant power becomes impracticable. Of course, manufacture and commerce demand a motor developing *full power* during a modern working day of *eight* hours. Observations relating to atmospheric diathermancy, continued during a series of years, enable me to assert that the augmentation of solar intensity during the middle of the day is so moderate that, by adopting the simple expedient of wasting a certain amount of the superabundant heat generated while the sun is near the meridian (as the steam engineer relieves the excess of pressure by opening the safety-valve), a uniform working power will be developed during the stipulated eight hours. The opening of the safety-valve, however, means waste of coal raised from a great depth at great cost, and possibly transported a long distance, while the radiant heat wasted automatically by the sun motor is produced by fuel obtained from an inexhaustible storehouse free of cost and transportation.

It will be proper to mention that the successful trial of the sun motor heretofore described and illustrated in *Nature* attracted the special attention of landowners on the Pacific Coast then in search of power for actuating the machinery needed for irrigating their sun-burnt lands. But the mechanical detail connected with the concentration at a single point of the power developed by a series of reflectors was not perfected at the time; nor was the investigation relating to atmospheric diathermancy sufficiently advanced to determine with precision the retardation of the radiant heat caused by increased zenith distance. Consequently no contracts for building sun motors could then be entered into, a circumstance which greatly discouraged the enterprising Californian agriculturists prepared to carry out forthwith an extensive system of irrigation. In the mean time, a simple method of concentrating the power of many reflectors at a given point has been perfected, while the retardation of solar energy caused by increased zenith distance has been accurately determined, and found to be so inconsiderable that it does not interfere with the development of constant solar power during the eight hours called for.

The new motor being thus perfected, and first-class manufacturing establishments ready to manufacture such machines, owners of the sun-burnt lands on the Pacific Coast may now with propriety reconsider their grand scheme of irrigation by means of sun power.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(*Continued from page* 349.)

CHAPTER XXIX.

EFFECT OF CHANGES IN THE RATE OF THE RULING GRADE.

As we have seen, the effect upon the cost of operating of changes in the rate of grades that are not the ruling grades is very little, and comparatively little money can be spent economically to make these reductions; in the case of any reductions of the ruling grade, however, the case is entirely different. The ruling grade, as has been before explained, is that grade which from any cause limits the weight of the trains that can be hauled over that section of the road. This limiting effect may arise from the rate of grade, the length of grade, or the relative position of the grade.

As has been shown in the preceding chapter, the steepest grade on a section may be so situated in reference to the preceding grades that its rate is very much reduced practically.

The train being able to take advantage of acquired surplus of speed to surmount it, therefore the RULING GRADE on a section of railroad is the steepest VIRTUAL GRADE.

The load that can be hauled by a locomotive on a level is in proportion to the weight which comes on the driving wheels, as the greater the weight on the drivers the greater will be the friction between the drivers and the rails, and the greater the resistance to the slipping of the drivers on the rails. By "slipping of the drivers" is meant the turning of the drivers without a corresponding movement of the locomotive. This is due to the fact that the amount of power applied to the drivers is in excess of the friction between the rails and the drivers, and the amount of power that is applied to the drivers depends upon the weight of train that is behind the engine, or the resistance to motion that must be overcome. Therefore, when this resistance to motion is greater than the friction between the surface of the rails and the drivers, the train cannot be moved. Either the drivers do not turn at all or else they turn without going ahead. As was said before, the amount of hauling or tractive power of the locomotive depends upon the weight upon the drivers. This is only true as to the relative tractive power of any number of locomotives under exactly the same circumstances.

As regards the absolute traction of any locomotive having a given weight on the drivers, this varies continually with the varying circumstances—that is, such circumstances as affect the coefficient of friction between the rails and the driving wheels. The condition of the surface of the rail is the most important factor in this respect, whether the rail is wet or dry, or whether covered with frost, ice or snow. But taking a dry rail in a fairly good condition, and everything in relatively good working order on the locomotive, the tractive power may be taken as one-fourth the weight on the drivers—that is, suppose the weight on the drivers is 40 tons, the tractive power of the locomotive would be 10 tons, or, in other words, it could exert a pull of 10 tons on any train behind it.

In considering the tractive power of a locomotive we have taken into account only the weight on the drivers, as that is the only element in the construction of the locomotive that the civil engineer need consider, from the fact that the engineer is not supposed to design the details of the locomotive, but simply regards it as a machine so proportioned as to be able to exert a power greater than the frictional resistance between the rails and drivers, and consequently having its tractive power limited by the amount of this friction, and indirectly by the weight on the drivers and the condition of the rails.

The limiting factors to the power of a locomotive regarded simply as an ordinary steam-engine are the dimensions and arrangements of the fire-box, or the capacity for generating heat, and the boiler capacity, which, in connection with the heat-generating capacity, limits the amount and pressure of the steam. The cylinders act simply as a means of conveying the force or power contained in the steam to the driving wheels, or the point where it is changed into work.

From what has been said it will be seen that one point to be studied in designing a locomotive is to throw as much of the total weight of the locomotive upon the drivers as is practicable. This has been accomplished in various ways. The weight of the locomotive rests upon the driving wheels and trucks. The driving wheels are those that are connected with the piston-rod by means of the connecting rod; these are called the main drivers, and those wheels which are connected with the main drivers by means of coupling rods are called trailing wheels. The remaining wheels under the locomotive are called truck wheels and serve simply to support the weight without in any way increasing the tractive power. By increasing the number of drivers there is more weight thrown on them, and the tractive power is increased. In the case of locomotives built for special service, where great tractive power is needed and speed of no consequence, such as engines to be used only in yards for switching, making up trains, etc., the whole weight is sometimes thrown upon two or three pairs of drivers, with no trucks at all; and, in order to make this weight as much as possible, and still not carry any useless load, the tank which carries the water, instead of being carried upon a separate car or tender, as is usually the case, is built around the boiler, and brings all its extra weight to bear on the drivers, thereby increasing greatly the tractive power of the locomotive. Another advantage of these yard or tank engines is the ease and facility with which they run round the sharp curves which of necessity occur in railroad yards. This is due to the fact that the whole wheel base is simply the distance between the drivers, and is consequently much less than if there were more drivers or trucks, as in ordinary locomotives.

It must be remembered, however, that these remarks as to weight on drivers must be accepted with certain practical limitations, imposed by the design and construction of the locomotives in ordinary use, and also by the necessity of considering the weight per wheel which the track will bear.

As has been stated, the tractive power of the locomotive may be taken at one-quarter of the weight on the drivers, with wheels and rails in fairly good condition, and the resistance to movement of the train behind the locomotive at 9 lbs. per ton on a straight and level track.

The weight of the train behind the tender is made up of two items: 1. Dead or non-paying load—that is, the weight of cars, etc., in which the freight or passengers are carried.

2. Live or paying load—that is, the freight or passengers, for the carrying of which the railroad company receives certain sums of money, from which the operating expenses, all charges, interest, etc., must be paid, and the surplus from which (if any) forms the profit on the money invested in the road, and (sometimes) goes to the stockholders in the form of dividends.

In considering the question of paying train-load, we will here take freight trains only, for the reason that more than three-quarters of all the business done by the railroads of the United States is in freight, and in every way the freight traffic is the ruling and important element in railroad business and the source from which the greater part of the revenue is drawn, except in the case of a few lines exceptionally placed—such as the lines between New York and Philadelphia, the New York, New Haven & Hartford, and a few others carrying suburban traffic near the larger cities.

The carrying capacity of the freight car has been practically doubled during the last few years, and a still further increase is probable. This increase in load has been very much greater proportionally than the increase in weight, until now we have freight cars which, when loaded up to their maximum limit, can carry nearly five times their own weight. In some few cases a load of five times the weight of the empty car has been actually reached, as with cars carrying coal, iron ore, stone, etc.

Taking the railroads of the country as a whole, however, this is not the case, and the proportion of paying to non-paying load is much less. This results from the fact that it is absolutely impossible that every car in a freight train should be fully loaded. This is not so much the case with through freight as with way freight, for the reason that for through freight, most of the material being billed to the same point and only forwarded at regular intervals, the cars can be more economically loaded. But in the case of way freight we reach the minimum of economy in the loading of the trains, and the dead load often equals and frequently exceeds the live load. As an average for all the railroads in the United States, we can take the total weight of car and load as 25 tons, of which 10 tons is the dead weight of the car, and 15 tons the average paying load per car. This same proportion will hold good of a train, and we may consider the average train behind the locomotive as made up of 40 per cent. dead load and 60 per cent. live load. This calculation, however, involves the assumption that the traffic in both directions is nearly equal; the actual figure for live load is, in practice, probably much less.

Any change in the ruling grade causes a corresponding change in the load that can be hauled by the locomotive, and the greater part of this change comes upon the paying load. Of course the actual amount of money that can be economically spent to reduce the rate per cent. of the ruling grade depends to a great extent upon what the rate of the ruling grade is, or, rather, what proportion the change will bear to the ruling grade—that is, much more can be spent to reduce a ruling grade from 0.5 per cent. to zero than from 2 per cent. to .5 per cent. For in the first case we reduce the resistance of the train in pounds per ton from 20 to 10, or one-half, thus doubling the load that can be handled, while in the second case we only reduce it from 50 to 40 lbs. per ton, and thus only increase the possible load one-quarter.

It must be remembered also that when we have arrived at any definite amount that can be expended to reduce the ruling grade, that it is to reduce the rate *per cent.* of the ruling grade, and not any definite number of vertical feet rise, as in the case of minor grades; and, further, that the reduction must be of the whole ruling grade contained in any one section and not simply of one or more parts of it. When the reduction in ruling grade is only made in some portion of it, the ruling grade proper remains the same as before, and the only gain to the railroad is that due to a reduction in any grade not the ruling grade.

CHAPTER XXX.

RELOCATIONS AND IMPROVEMENTS.

In locating a railroad, the possibility should always be borne in mind that, however small the amount of traffic may be that will be done by the road during the first few years, this traffic may grow to enormous proportions in the near future, either by the development of the resources of the section of country through which it runs, or by its becoming in the course of time a link in some long trunk line.

In either case it will be justifiable for the road to ultimately expend a vast amount of money in reducing its grades, curves, and, where this increased traffic is all hauled over its own line, in reducing its length. When the road considered, however, simply forms a part of a trunk line, it may be a positive loss to reduce its length.

This is due to the fact that in any through line made up of a number of independent companies, the amount charged for transportation is not based upon the exact distance hauled, and does not vary as that distance. It is wholly governed by competition and outside circumstances that are to only a very slight extent controlled by the actual distance. But although the rates charged are not proportional to the distance hauled, still, when it comes to dividing this rate among the different roads that go to make up the through line, the division is usually in exact proportion to the number of miles of road each company owns, so that the greater the proportion of the whole that is owned by one company, the greater will be that company's receipts.

Therefore, if a company forming part of a through line spends money to reduce the length of its road, it is simply doing an act of charity.

It loses the interest on the expenditure and reduces its share of the gross receipts, while the other companies that make up the line are the gainers.

For example, suppose a through line to be composed of three separate railroads, of the following lengths: *A*, 50 miles; *B*, 30 miles, and *C*, 20 miles, making a total of 100 miles.

Suppose the rate per ton for transportation to be 90 cents, then a division of this rate proportionately to the length of each road would give: *A*, 45 cents; *B*, 27 cents, and *C*, 18 cents.

Now by an expenditure of a large amount of capital, the length of *A* is reduced 10 miles. The freight rate remains the same, as it is regulated by competition and other outside influences that have nothing to do with the length of the line. Dividing this rate proportionately to the new lengths, *A* receives 40 cents, *B*, 30 cents, and *C*, 20 cents.

That is, *A* loses 5 cents on every ton of freight, *B* gains 3 cents, and *C* 2 cents, when *A* reduces its length 10 miles. To look at the other side of the question, suppose

A to be 60 miles, *B*, 30 miles, and *C*, 20 miles, the rate remaining the same. Then the proportion would be: *A*, 48.6 cents; *B*, 24.3 cents, and *C*, 16.2 cents, showing an increase for *A*, with its increase in length, and a corresponding loss for *B* and *C*.

From this we see that that road will make the most money that forms the longest part in the shortest through line between any two points.

Suppose the whole line, however, belonged to *A*, and the rates were still fixed without regard to distance, the more *A* could reduce its length the better.

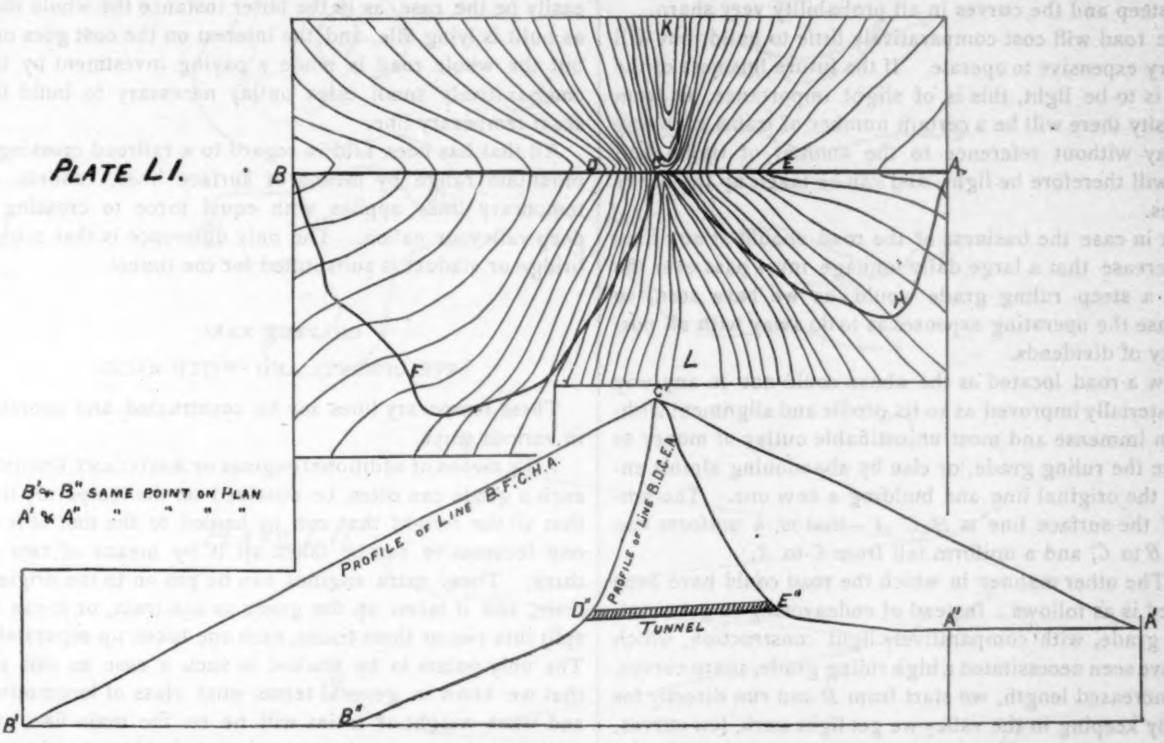
In some cases, however, even when *A* is only a part of a trunk line, it has received the same proportion of the receipts after its length has been reduced that it did before, on account of the gain to the line as a whole from this decrease in length. This is called "constructive mileage," and whether *A* will receive it or not depends in the majority of instances not upon the merits of the case, but upon the power of *A* to enforce its claims.

Under any circumstances, however, it is true economy to reduce the curves and grades as much as possible.

In building a new road (particularly in a new country) the amount of capital available for the enterprise is often very limited, and even if this is not the case, the amount of future traffic is problematical, and it is not justifiable to go beyond a certain reasonable amount of expenditure in order to reduce the curves, grades, or distance.

What this amount may be is fully set forth in Chapter XXV. But the amounts obtained there simply give the values of these changes for some assumed or definite amount of traffic, or at least a definite number of daily trains. But in many cases where the probable or possible number of daily trains is very large, so that economically a very large absolute amount of money may be spent for each degree of curvature or foot of grade saved, it is impossible to obtain this amount of money at any reasonable rate. We then have two courses open in regard to the railroad.

PLATE LI.



With the limited amount of available capital we may locate the best possible road between the terminals that can be built for the money, using such curves, grades, and length as shall best suit the topographical features of the country, within the limits of the allowable expenditure.

If this road runs through a rough, mountainous country, it will have sharper curves, more of them, steeper grades, and greater length than would be necessary were it possible to expend more money. In most cases it will be found that the alignment and profile of the road could be very much improved with no increase and often a great decrease in the cost of construction, for the greater part of its length, provided it were possible to vastly increase the cost of construction at some few points.

Of course the total cost of the railroad would be very much increased. Thus, suppose we have the terminal stations so situated that there is a range of mountains between them. The railroad between these points may be located in either of the following ways:

1. The road may be located as a surface road—that is, one where the grade line is kept as near the surface of the ground as possible, thus doing away with any cuts or fills, or any heavy and expensive work. In order to locate a line of railroad such as this, doing away with all heavy work, or at least keeping the cost of construction per mile within certain limits, we must use a much steeper ruling grade, much sharper and more numerous curves, and a great increase in distance.

Thus, in Plate LI, let *K C L* represent a range of mountains, and *A B* the terminal stations, *C* the narrowest as well as the lowest part of the range. In order to locate a surface road from *B* to *A*, it is necessary to swing to the right or left of *B*, and climb the slope of the mountain at a greater or less angle to the contour lines, depending upon the angle of slope of the surface and the rate of grade that is being used, in order to be at such an elevation when *C* is reached that a deep cut will not be required. In locating a line such as this, the pass *C* would

be the proper place to commence the work. Decide how much cut can be afforded there, and what the rate of grade within certain limits shall be. Then, dropping both ways from *C*, find an approximate surface line that has the required rate of grade (much less than what is to be used as the ruling grade, as the compensation for curvature must be taken out afterward), and with this line get to the terminal stations in the shortest distance possible. When this surface line has been plotted with all its angles (usually no curves are run in on this first line), then locate a line on the paper as nearly identical with this surface line as possible, when the angles in the broken surface line are replaced by curves of a radius sufficient in length to permit the running of trains around them. Unless the distance between the terminal stations be enormously increased, the ruling grade on both sides of the pass will be very steep and the curves in all probability very sharp.

The road will cost comparatively little to build, but will be very expensive to operate. If the future business of the road is to be light, this is of slight importance, as from necessity there will be a certain number of trains each way per day without reference to the amount of traffic, and they will therefore be light, and can be taken up the heavy grades.

But in case the business of the road should at any time so increase that a large daily tonnage must pass over the road, a steep ruling grade would, as we have seen, so increase the operating expenses as to do away with all possibility of dividends.

Now a road located as the above could not in any way be materially improved as to its profile and alignment without an immense and most unjustifiable outlay of money to reduce the ruling grade, or else by abandoning almost entirely the original line and building a new one. The profile of the surface line is $B' C A'$—that is, a uniform rise from *B* to *C*, and a uniform fall from *C* to *A*.

2. The other manner in which the road could have been located is as follows: Instead of endeavoring to get a uniform grade, with comparatively light construction, which we have seen necessitated a high ruling grade, sharp curves, and increased length, we start from *B* and run directly for *C*. By keeping in the valley we get light work, few curves, and for a certain distance, say to *D*, a very light grade. On the other side of the pass we have the same alignment from *E* to *A*. The profile of this line is shown at $B'' D'' C'' E'' A''$, and at D'' the ground begins to rise very rapidly to C'', and then falls as rapidly to E''.

The horizontal distance from D'' to E'' is very little, but the rise and fall to be overcome is much greater than it is possible to surmount by any trains and locomotives that can be economically run over $B'' D''$ and $E'' A''$.

If there is sufficient available capital, and the business of the road will warrant the expenditure, a tunnel should be run from D'' to E''.

This would require, however, a great increase in the amount of time needed to finish the construction. The better way would be to run the line from *B* to *D* and from *E* to *H*, getting as low grades and as perfect alignment as possible. Then from *D* to *H* build a temporary road over the pass as cheaply as possible, and operate it as a separate division by one or the other of the various methods that will be described.

Then, when the resources and business of the company make it advisable, build the tunnel $D'' E''$. When this is done all the road from *B* to *D* and *E* to *A* will be utilized, and the only portion that will have to be abandoned is the cheaply built, temporary road over the pass *D C E*.

Another case may and often does arise where it is advisable to build the temporary line in the first place, even when the business and resources are such as to make the building of the tunnel justifiable, and that is in order to gain time.

It frequently happens that a great advantage may be secured to a new road if it can be opened by a certain time, as when other competitors are trying to reach the same point. It may also happen that a large part of the road is completed, and that the tunnel section alone remains unfinished; here the interest on the capital invested in building the remaining portion of the road, which will accrue during the time which it will require to build the tunnel, may exceed the cost of the temporary road. This may very easily be the case, as in the latter instance the whole road as built is lying idle, and the interest on the cost goes on; but the whole road is made a paying investment by the comparatively small extra outlay necessary to build the short temporary line.

All that has been said in regard to a railroad crossing a mountain range by means of surface lines, tunnels, or temporary lines applies with equal force to crossing a deep valley or cañon. The only difference is that a high bridge or viaduct is substituted for the tunnel.

CHAPTER XXXI.

DEVELOPMENTS AND SWITCH-BACKS.

These temporary lines my be constructed and operated in various ways.

1. By means of additional engines or ASSISTANT ENGINES such a grade can often be obtained on the temporary line that all the freight that can be hauled to the foot of it by one locomotive can be taken up it by means of two or three. These extra engines can be put on to the original train, and it taken up the grade as one train, or it can be split into two or three trains, each one taken up separately. The only points to be studied in such a case as this are that we know in general terms what class of locomotives and what weight of trains will be on the main line, and also from the reconnoissance what probable rate of grade may be obtained on the temporary line.

We also have some general estimate as to the probable amount of future traffic, and we must also know what will be the cost of operating each assistant engine necessary.

From a combination of the different points of information we can decide how many extra locomotives and how much the gain would be to the road by this method of operating; also what the maximum allowable ruling grade of the temporary line may be.

This method of surmounting considerable elevations is capable of much expansion beyond the narrow limits to which we have confined ourselves in the foregoing chapter.

In the example we have taken, *D E* is comparatively short, and the line for the use of assistant engines is merely a temporary expedient, to be replaced as quickly as time, resources, and business permit by a tunnel. But the same principle may be applied on a much larger scale and for permanent use. Thus, take a line of road 200 or 300 miles long, running through a country having such topographical features that any line of uniform grade would necessitate a high ruling grade. It would be much more economical, from both the operating and constructing stand-

points, to so locate the road that, if possible, all the heavier grades shall come in one operating section, making the ruling grade of this section comparatively steep, while the remaining sections preserve a much lower rate. By so establishing the grades on a road, all the engines are worked up to a point much nearer their total capacity, and on the section with the heavy ruling grade more engines can be used, and still every engine do its fair share of work.

Where the section with the steep grades is so short that it can be worked by assistant engines, helping up the different trains as they come along, one assistant engine can often replace three or four engines that would be necessary were the same altitude surmounted by a uniform grade.

2. The second method of surmounting considerable altitudes, where only the ordinary locomotive is to be used as tractive power, is by means of SWITCH-BACKS.

These may be and are constructed for both temporary and permanent use.

Where a definite weight of train is to be hauled over a line of road by a locomotive, the tractive power of which is known, the grades on that road cannot exceed a certain angle of inclination, and in order to surmount any elevation, by means of any required rate of grade, the only element necessary is sufficient distance.

The gaining of this distance required, in order not to exceed the maximum rate of grade, is called DEVELOPMENT—that is, running out of the direct course between the terminal stations *simply* to gain distance.

Where the topography will permit, the ordinary method of development is by swinging to the right or left of the direct line; fitting the line to the ground as closely as possible, and so meandering back and forth, always ascending at the required rate of grade until the required amount of distance has been obtained and the highest point passed. In this method the line as located is similar to any ordinary railroad line, being made up of tangents and curves, as shown in Plate LII, fig. 1.

In this location the curves must be of such a radius as to allow of the free running of trains around them. To run in curves of such a radius requires a certain amount of space, and to do this in the most economical manner requires a very broken and peculiar topography.

Some examples of gaining distance in this manner will be given in a future chapter.

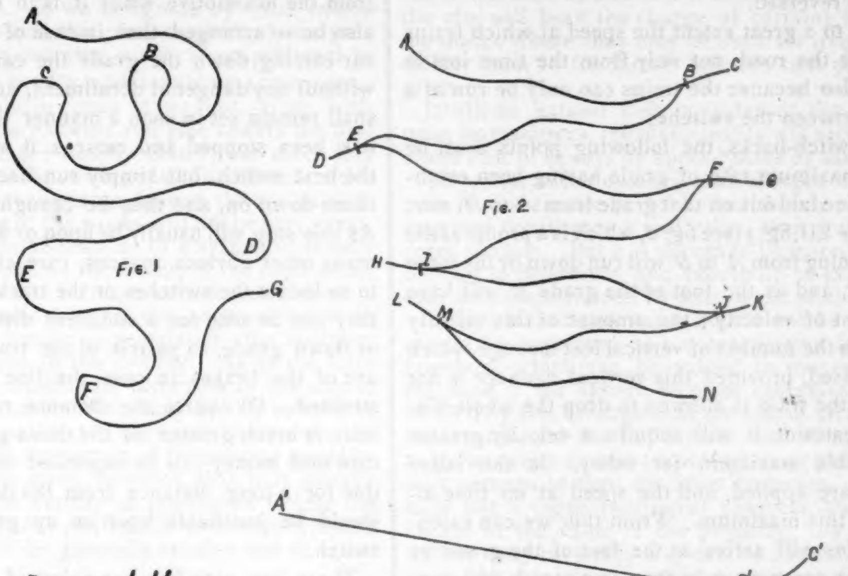


PLATE LII.

When, however, the line of road has to ascend the side of a mountain that is comparatively regular and uniform, so that there is no chance of developing to gain distance in the ordinary manner, the following expedient is often used, and could be used much oftener than it is if engineers would only put more time and study upon its many relative advantages, and the great gain both in time and money that may often be made by its adoption.

This method is what is known as a SWITCH-BACK—that is, the line of road, in being developed to gain distance, does not curve back and forth, as shown in Plate LII, fig. 1, in such a manner that trains can be hauled in one direction over the whole length, but zigzags in the manner shown in Plate LII, fig. 2.

In this we will suppose the road is located from *N* to *M*, upon the maximum grade ; at *M* the direction is simply

reversed, and the road from M to J has the maximum grade, then from J to I, I to F, etc. In this manner as much distance may be gained as is necessary, and no more space is required than the width of the road-bed, plus any excess due to cuts or fills.

In this manner a railroad may be located in a most economical manner in regard to construction in a most difficult country. In regard to operating expenses it can at once be seen that trains cannot be run over switch-backs as economically as over a spiral, a series of loops, or any of the ordinary forms of development surmounting the same height with the same grade, from the fact that at every change of direction in the switch-backs, as M, J, I, F, E, the train has to come to a full stop and the direction in which it runs is reversed.

This reduces to a great extent the speed at which trains can be run over the road, not only from the time lost in stopping, but also because the trains can only be run at a limited speed between the switches.

In locating switch-backs, the following points must be studied: The maximum rate of grade having been established, and the line laid out on that grade from A' to B', etc., as shown in Plate LII, fig. 3 (see fig. 2, which is a profile of the line), a train running from A' to B' will run down by the force of gravity alone, and at the foot of the grade B' will have a certain amount of velocity; the amount of this velocity will depend upon the number of vertical feet through which the train has passed, provided this vertical distance is not so great that if the train is allowed to drop the whole distance without restraint, it will acquire a velocity greater than the allowable maximum for safety. In this latter case the brakes are applied, and the speed at no time allowed to exceed this maximum. From this we can calculate that all trains will arrive at the foot of the grade or at the switches at approximately the same speed, and consequently that the same amount of force per ton of weight will be required to bring them to a stand-still. The most economical and practically the best method of doing this is to extend the track beyond the switch, with a gradually increasing up grade, until it becomes sufficiently steep and long to bring the train to a stand-still by means of the resistance due to this grade.

The reverse in the direction of the grade from down to up at B', E, F, etc., must be made by means of a vertical curve, the point of the curve, which has a horizontal tangent, being at the switch, as at B' E, etc., and the grade rising each way toward A' and C, and D' and B. From the switch B' in the direction C for a distance greater than the greatest length of train, the rate of grade must not exceed the maximum. In order that trains ascending may be able to clear the switch without trouble, the rate of ascent beyond this point can be very much increased, and up to a certain limit the more the better. The proper establishment of this stopping grade is an extremely simple matter, and requires only a careful study of the chapter upon the Effect of Velocity upon the Movement of Trains. By an application of the principles there explained, we can estimate at once the exact number of vertical feet rise necessary to bring the trains to a stand-still. The horizontal distance that shall be employed to obtain this amount of rise depends within certain limits upon the topography of the country in each particular case.

Wherever possible (and we may say that where switch-backs are advisable it is always possible) switch-backs should always be located in pairs, with the distance between any pair as short as possible.

The reason of this is that a train either ascending or descending has to run backward after passing one switch-back until it has passed another. There are many objections to this in the practical rapid running of trains. One of the most important is that unless the locomotives used are of special construction for the purpose they cannot with safety, speed and economy run backward over sharp curves.

Another point that is indispensable to the economical and rapid operation of switch-backs is that the switches should be perfectly automatic, or, better still, that the locomotive driver should be able to set them as he chooses from the locomotive while it is in motion. They should also be so arranged that in case of a runaway or a loose car coming down the grade the car can pass the switch without any danger of derailment, and also that the switch shall remain set in such a manner that when the runaway has been stopped and returns it will not run down to the next switch, but simply run back on the same track it came down on, and thus be brought to a permanent stop. As this stop will usually be upon or near the switch, and for many other obvious reasons, care should always be taken to so locate the switches or the track leading to them that they can be seen for a sufficient distance on either the up or down grade, to permit of the trains being stopped by use of the brakes in case the line for any reason is obstructed. Of course the distance required for stopping a train is much greater on the down grade, and much more care and money can be expended to make the switch visible for a long distance from the down grade track than would be justifiable upon an up grade approaching the switch.

There are very few examples of switch-backs in permanent use, as there are undoubtedly many disadvantages connected with their use upon roads of large traffic, but for temporary expedients for passing great elevations they are of invaluable assistance to the engineer.

Some examples of the most noted switch-backs, both for permanent and temporary use, will be given in a succeeding chapter in connection with examples of spirals, loops, etc.

The advantages of switch-backs are as follows: A reduction in the number of degrees of curvature, and a great decrease in the cost of construction. The amount of curvature can usually be reduced to one-half or less of what it would be in surmounting the same elevation by the ordinary system of development, and in many cases the cost of construction can be reduced in a similar proportion. The distance required to surmount a given elevation by means of a given rate of grade is also less on any line that reduces the amount of curvature, as the rate of grade has to be reduced for each degree of curvature, and consequently more distance is required to surmount the same elevation. This, therefore, makes a saving in distance in the use of switch-backs.

By far the most important gain made by the use of switch-backs, however, is in the first cost of construction.

The other two advantages named—reduction of length and curvature—are more than offset by the disadvantages—namely, more or less danger, loss of time, and the general inconvenience attending any attempt to do a large and rapid business.

(TO BE CONTINUED.)

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées*.)

(*Continued from page* 358.)

IX.—THE COST OF A SYSTEM OF SEWERAGE.

THE dimensions and consequently the cost of a sewer depend on two elements, the quantity of water to be carried and the available fall.

Everything else being equal, the expense of a system to carry off the waste water from a city will decrease as the general topographical conditions permit us to adopt greater degrees of fall. However, we are not obliged to believe that in cases nearly alike the variations from this cause will be very important. If we designate by r the radius of a pipe sewer, or one-half the greatest width of an ovoid sewer, the capacity for carrying water is proportional to $\sqrt{r^5 I}$. If we double I we diminish r only by 15 per cent., or if we triple I we diminish r only 25 per cent. Now, both in the case of the masonry sewers and pipe sewers the first cost increases a little more rapidly than r, but much less so than r^2, so that when the average fall in different cities does not attain exceptionally large figures the variation in the size and importance of the works will not be very great.

The expense of the establishment of a system of sewers per inhabitant will depend on the density of the population, and will have a tendency to increase as that diminishes.

As an example, we will compare the length of sewer in two cities of unequal density of population, the ordinary duty being in proportion to the density. As to the rain-water, it is making a hypothesis favorable to the city of less population to assume a reduction in the volume of these waters proportional to that of the ordinary duty, resulting from the smaller proportion of the surface paved or built upon. It may be noted, however, that it is usually the case that where the density of population is less the proportion of surface built upon will be somewhat greater, because the houses will be generally smaller and of fewer stories.

The same length of sewer should, on these assumptions, have in two cities a capacity for carrying water in proportion to the density—that is, to the number of inhabitants per hectare, which we may designate by N. Then for the same value of I, N will be proportional to $\sqrt{r^5}$—that is, r will be proportional to $N^{\frac{2}{5}}$; therefore we will not go contrary to the result of experience in assuming that the expense to construct a sewer will be proportional to $r^{\frac{5}{4}}$. We will see then that the expense of an equal length of sewer in two cities will be approximately proportional to the square root of the density, and the expense per inhabitant inversely proportional to the same square root.

This proposition, although it is only an approximation, is interesting as showing us that if we wish to render possible the construction of a complete system of sewers, even in small and moderate-sized cities, where the population is generally less dense than in large cities, and in which the resources per inhabitant are less, we will meet with financial difficulties which can only be surmounted by strict economy in design and construction.

However little we depart from these principles, we will reach in certain cases some exceptional results. I recently had in my hand a plan for sewers which had been prepared without any reference to the department of Ponts et Chaussées for a provincial city of 55,000 inhabitants, where the annual revenue was somewhat less than 1,500,000 francs; the system would not have cost less than 5,000,000 to 6,000,000 francs, without counting the cost of maintaining the large galleries and the expense of cleaning them out.

If modern hygiene were only attainable at such a price we would be obliged to do without it.

Happily it is possible, by following the principles which we have indicated, to avoid such excessive cost; by exercising careful economy in small cities and by limiting also in certain points subterranean carriage for rain-water, we will usually be able to establish a proper system for disposing of waste water at a cost which may be provided for by a moderate tax.

The example of Berlin, where the density of population is much greater than in a city of moderate importance, and where, on the other hand, the topographical conditions are extremely unfavorable, permits us to indicate an average figure of 30 francs per inhabitant. This does not include the house connections, which must be paid for by the owner.

This first cost corresponds to an annual charge of 1.50 francs, which will perhaps be doubled by the cost of erecting the machinery intended for the purification of water at the point of discharge. Sewage water, owing to the fertilizing properties which it contains, represents a very considerable agricultural value, and it will in time probably be the case that the payment for the use of this will be a considerable item in the income of a city; but in the present actual state of affairs it is most prudent to assume that the city will bear the charge of carrying these waters to the places where they may be used for irrigation, and will deliver them to the farmer without cost or at a very low price.

It will be natural that, considering the many demands upon its resources, the municipality will seek to regain part of the cost of sewers by special taxes or assessments.

Certainly, in our opinion, such charges will be justifiable even for the service to public health only; for this kind of progress constitutes a real value, even from an economic point of view. But it is always to be feared that this value, difficult to determine, and especially to express in money, may be misunderstood by part of the public.

In order that new taxes should not be unpopular, they should be presented as a compensation for some service rendered, which can be valued in money. This will be the case if the system receives excrementitious matters. In fact, by this arrangement the cost of privy-vaults will be suppressed and the builders of new houses will not have to make vaults or cess-pools, and those which already exist may perhaps be used for other purposes. In this case we have not a vague contingent progress, but an evident increase in the value of the property. By this increase it will be easy to justify a system of assessments which will repay the municipality without resting too heavy upon the inhabitants.

X.—CONCLUSION.

Before closing these notes we must offer an excuse for having made such frequent use of examples taken from foreign countries. We fear the reproach of doing wrong to our French engineers by contrasting their practice as defective with the practice of foreign engineers. But this is not the truth.

The problem of which we have treated—a complete method or system for disposing of the waste water of an entire city—has not yet to our knowledge been treated in a single French city, with the exception of Paris, and the example of that city is, for reasons which we have indicated, to be admired but not imitated. The sewers which have been made here and there in the different provincial cities, chiefly for the purpose of disposing of the rain-water, cannot be treated in the same way as a complete system intended to dispose of the waste water. That is a problem which in France is new. Now English experience in this matter, although recent, is already considerable, and German engineers, who have so far simply applied English methods, have distinguished themselves by numerous and remarkable creations. It is necessary to refer to the experience and practice in these countries, not because they are the best, but because they are the only ones.

These new demands of sanitation tend more and more to become imperative in cities and to take place with the supply of pure water among the essential functions of the municipality.

Engineers, who are consulted in all questions of public works, have in this matter a great influence to exert, but this influence should be exerted in the interest of public health.

They must remember, however, that it is not only public health which must be considered; we must maintain on the other hand, in the plans and in construction, that strict

economy, which, in presence of the increasing demands of our time, is the only safeguard of municipal finance.

AN INDIAN BRIDGE OF BOATS.

(Paper by H. A. S. Fenner, Superintending Engineer, in the *Indian Engineer.*)

BEFORE describing the boat-bridges used in the Punjab, a brief description of the leading characteristics of the rivers will make their use more intelligible.

The chief rivers of the Punjab rise in the Himalayas: in consequence, early in April they commence to rise, due to the melting snows; and their volume, until the rainy season commences, varies entirely according to the climatic influences at work in the mountains. The melting of the snow, checked by night, sensibly influences the discharge for many miles beyond the debouche of the river into the plains. The rainy season lasts from about June 15 to the end of August, with occasional storms in September. The heavy floods generally occur early in August. As the rainfall in the winter months is comparatively small, the discharge of the rivers during the cold weather is quite insignificant as compared to that in the rainy season.

In the plains, the level of the riparian country is low, and the flood-water occupies a large area. In the cold weather the river is represented by numerous tortuous channels, some deep, some shallow, and the majority dry, utterly preventing the use of a ferry. Therefore, until the railroad necessities made bridging these rivers imperative, boat-bridges, from their portability and simplicity, were extensively used.

Perhaps the best example of this peculiarity is that of the boat-bridge across the Indus at Dera Ismail Khan. In the rains the Indus at this place inundates a tract of country 25 miles wide; of course, at this season, a bridge of any sort is out of the question, and a ferry is used. In the cold weather—taking for example that of 1885—the bridge was in four sections, with an aggregate length of 3,448 ft.

The boat-bridge illustrated by the accompanying drawings is that over the Indus at Attock. Here the river is confined by hills on either side. In consequence, the depth and velocity of the river varies immensely. The average rise of the river above the cold weather level is 56 ft., and a rise, due to a landslip occurring in the mountains, has been recorded of 96 ft. above the same zero.

Fig. 1

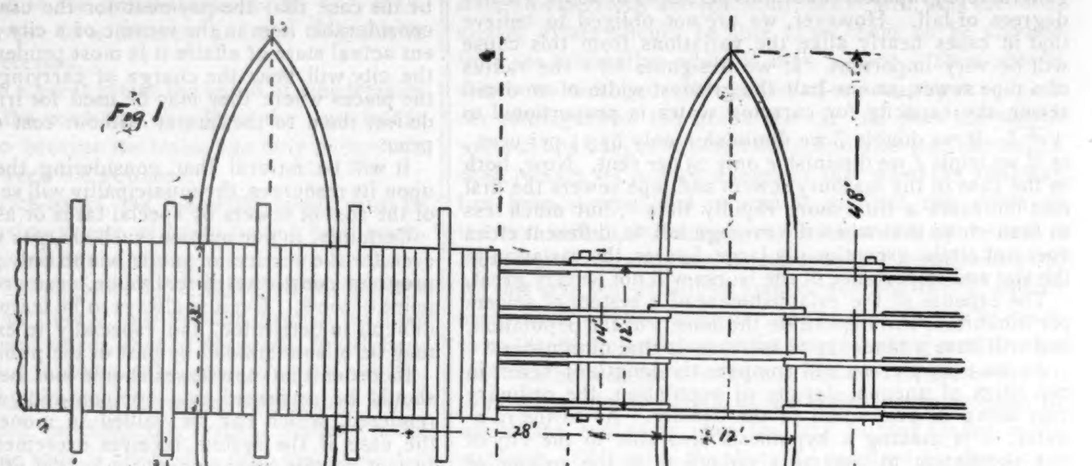


Fig. 2.

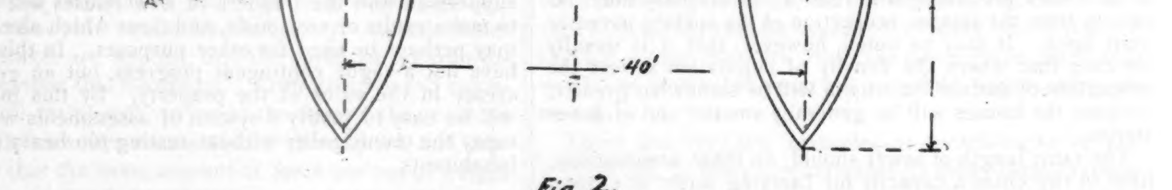
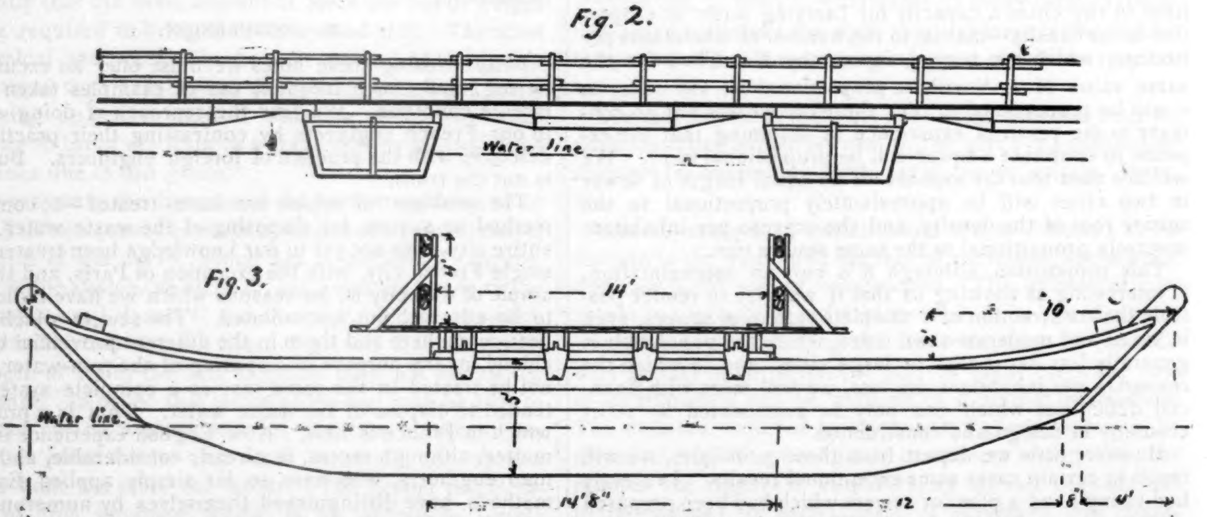


Fig. 3.



The Indus has now been permanently bridged by a very fine iron structure, carrying the railroad on the top and the road on the lower portion of the girder, so that the boat-bridge is not now used. When put up, it was sometimes in two sections, but generally one was sufficient, with a total length of about 1,200 ft. The bridge was usually kept up from September until the end of May.

Of the accompanying sketches, fig. 1 is a plan of a short section of the bridge ; fig. 2 is a longitudinal section of the same, and fig. 3 is a cross section. Fig. 4 shows, on a larger scale, one of the trussed beams which carry the roadway between the boats. Fig. 5 is a map showing the location of the bridge and the arrangement of the anchors ; in this the anchor-chains are shown by the dotted lines.

In constructing the bridge the main cable is, in the first instance, got into position by means of smaller cables, fastened to the rocks or to piers purposely built, and is buoyed by ropes anchored at intervals. When this is secured, the boats are gradually got into position, commencing from one bank. As the boats are placed they are kept apart, as shown in the plans ; they are anchored and other cables are laid until the bridge is safely secured, after which the roadway is laid. Cables and anchors are added as the state of the river demands, and if it is necessary to keep the bridge up after the river has attained a certain level, as was the case during the last Cabul War.

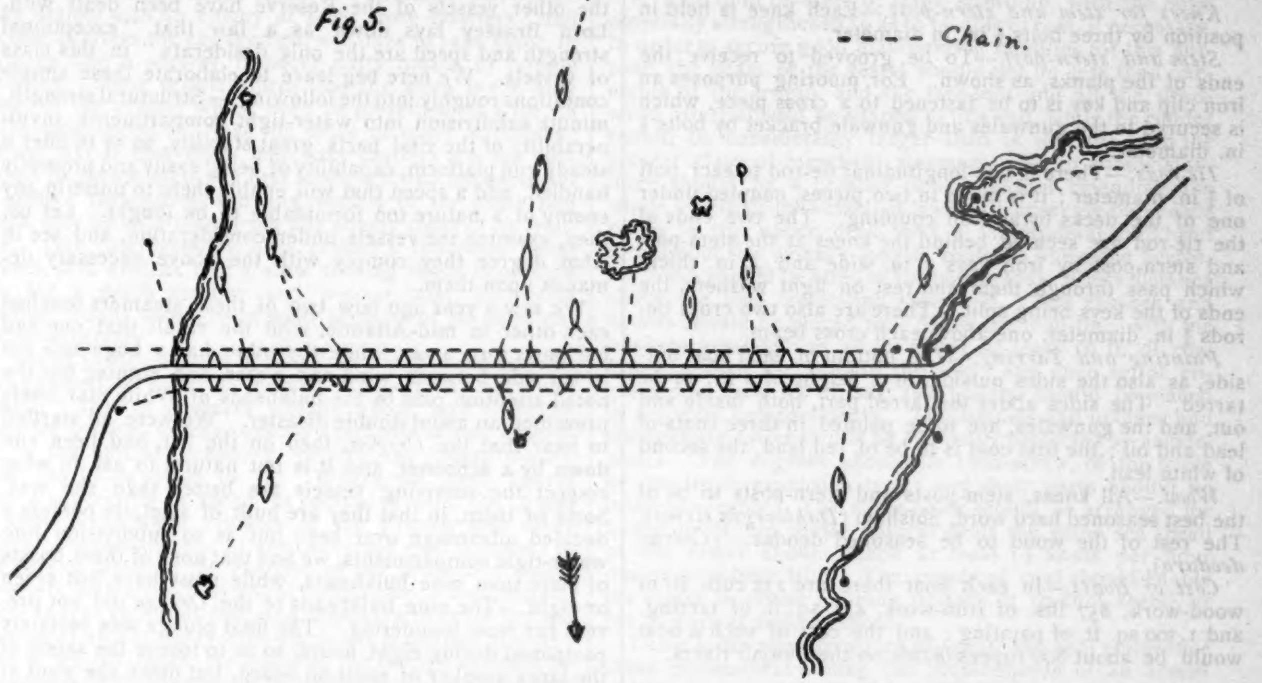


Fig. 5.

The bridge illustrated is shown in a straight line, but it has been found best to allow the bridge to assume the outline, in plan, of a catenary curve ; the advantage is obvious.

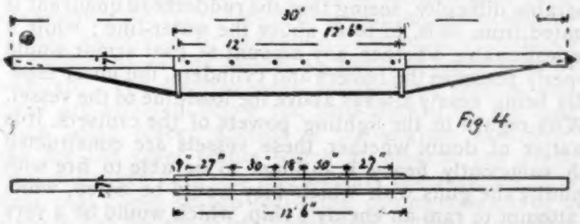


Fig. 4.

Temporary roads to boat-bridges across the dry river beds are inexpensively made by laying down coarse long grass, usually found by the river itself ; on this sand or clay, if obtainable, is thrown, and the traffic speedily consolidates it.

Anchors of European manufacture are used, especially in such streams as the Indus, but rough anchors are often made and used, which are both effective and cheap, and which can be simply abandoned when the bridge is taken down on the river rising.

These bridges are expensive to maintain, though the first cost, as compared with that of a permanent bridge, is small. In the case of a river liable to sudden small floods, a number of experienced men are necessary to take needful precautions to prevent the bridge being swept away.

SPECIFICATIONS FOR A BOAT.

General.—The boat which is shown in the accompanying sketches has an extreme length of 48 ft., and breadth 12 ft., and depth midships 5 ft.; a tie-rod, running fore and aft, stiffens it against strains due to grounding.

Floor planks.—The outer floor planks to be $2\frac{1}{2}$ in. thick, the others $1\frac{3}{4}$ in. The planks not to exceed 12 in. in width. Each plank is to be secured to the floor beams by two iron spikes $\frac{3}{8}$ in. square and 7 in. long, the centre plank, and none other, is to be thickened toward the stern and stern-post up to 3 in.

Floor beams.—To be 2 ft. apart, center to center ; provision to be made to pass the bilge-water under these beams.

Hull planking.—To be 2 in. thick throughout, excepting in the curved part near bow and stern, where they may be reduced to $1\frac{1}{2}$ in. The planks not to exceed 9 in. in width. Each plank is to be secured to every rib it crosses by two square spikes of soft iron riveted up to washers. Each spike is to be tapering, to be $\frac{3}{8}$ in. square near the head. Twisted spike nails to be used for securing the ends of the planks to the stem and stern-posts. Each of these nails to be 7 in. long, and $\frac{3}{8}$ in. square, and with only one turn or twist ; the spikes are not to be less than 4 in. apart. Ordinary spike nails $\frac{3}{8}$ in. square, and placed 5 in. apart, to be used to secure the bottom side plank to the outside bottom plank.

Ribs.—To be of deodar wood and to be placed 2 ft. from center to center. An iron knee, $\frac{3}{8}$ in. thick, is to connect each rib with the floor beam on which it rests. This to be secured by six spikes of iron $\frac{3}{8}$ in. square, which are to pass entirely through the wood-work and riveted up to sunk washers. The ribs simply rest on the floor beams, no joint of any kind being used ; all ribs are to be 6 × 3 in.

Gunwales.—The longest timber procurable should be reserved for the gunwales and the first side plank below it, which should break joint with each other. The pieces of timber forming the gunwales are to abut against each other with plain square heads, and are to be secured with two straps of iron 2 in. × $\frac{1}{2}$ in., and 6 ft. long, countersunk into the wood and bolted to it by six bolts $\frac{1}{2}$ in. in diameter. A 9-in. spike, $\frac{3}{8}$ in. square, is to secure the gunwales to each rib.

Deck beams.—Each deck beam is secured to each rib by two spikes of soft iron $\frac{3}{8}$ in. square. In the undecked portion of the boat a deck beam will not be required at every

pair of ribs. Two stout deck beams 6 × 6 in. are to be secured both to ribs and gunwales by rivets of ½ in. diameter; all other deck beams are 7 × 1½ in.

Cross beams.—Two are required, each 8 × 4 in., and are to be secured to the vertical props by ½ in. diameter bolts.

Vertical props.—Two are required, one at each angle of the tie-rod; each is to be 5 in. square; each prop is secured to the floor beams by two clinched spikes; each stands fair over the floor beam, which is not to be in any way cut.

Deck planks.—To be 1 in. thick, secured to each beam by two 3½ in. nails. The center of the boat is open. The deck only extends 8 in. from each end. A hatchway is left over the stem and stern-post knees, as shown.

Knees for stem and stern-post.—Each knee is held in position by three bolts ¾ in. in diameter.

Stem and stern-post.—To be grooved to receive the ends of the planks, as shown. For mooring purposes an iron clip and key is to be fastened to a cross piece, which is secured to the gunwales and gunwale bracket by bolts ½ in. diameter.

Tie-rods.—There is one longitudinal tie-rod to each bolt of ¾ in. diameter; it is made in two pieces, coupled under one of the decks by an iron coupling. The two ends of the tie-rod are secured behind the knees at the stem-post and stern-post by iron keys 1 in. wide and $\frac{5}{16}$ in. thick, which pass through them and rest on light washers, the ends of the keys being split. There are also two cross tie-rods ¾ in. diameter, one above each cross beam.

Painting and Tarring.—The bottom of each boat outside, as also the sides outside, to a height of 1 ft., to be tarred. The sides above the tarred part, both inside and out, and the gunwales, are to be painted in three coats of lead and oil; the first coat is to be of red lead, the second of white lead.

Wood.—All knees, stem-posts and stern-posts to be of the best seasoned hard word, Shisham (*Dahlbergia sissoo*). The rest of the wood to be seasoned deodar. (*Cedrus deodara*).

Cost of Boats.—In each boat there are 234 cub. ft. of wood-work, 857 lbs. of iron-work, 434 sq. ft. of tarring, and 1,300 sq. ft. of painting; and the cost of such a boat would be about 800 rupees ($286) on the Punjab rivers.

English Armed Cruisers.

(From the London *Engineer*.)

DURING the last few years we have been told to comfort ourselves in that while our recognized navy will be competent to deal with the fighting ships of an enemy, we have a large reserve in the shape of armed merchant vessels, which would be able to protect our ocean routes from the *Alabamas* that a hostile Power would naturally equip to harass our immense floating trade. This was a happy idea on the part of the Admiralty, one eminently calculated to soothe the public mind. There was a sense of protection and security conveyed in the very name of "armed cruisers," of which the naval administrators knew how to take advantage. Accordingly we were told that arrangements had been made with certain owners of mail steamers, by which the best and fastest of their vessels might be taken up in time of emergency, fitted with guns, and sent out to protect the ocean highways. In theory this was really an invaluable proposal, which seemed to lighten the burden of anxiety resting upon the hearts of all true lovers of their country; but theory will never save us from ruin, so we propose to consider a few practical points in regard to the merchant cruisers.

We all remember the Russian scare of 1885, when first these vessels were taken up seriously, and we remember the time that elapsed before even one of them was in a condition to set out on a war-cruise—the *Oregon*, in fact, being the only one of all those taken up which was completely equipped for the purpose intended. We will assume that since definite arrangements have been formed for what might be called a standing fleet of cruisers, due preparations will be made and stores and fittings will be at hand to equip them with the least possible delay, so that they will be ready within, say, a week of their arrival at a home port, and, allowing also that the destinies of England will not be decided in so short a space of time, we will proceed to review what material we have before us in the shape of the vessels.

On reference to Lord Brassey's "Naval Annual," we find under the heading of "Royal Naval Reserved Merchant Cruisers," 19 vessels at present afloat, ranging in size and speed from the *Umbria*, of 7,718 tons and 18½ knots, to the *Celtic*, of 3,867 tons and 14 knots. There are also two new White Star boats of 10,000 tons, which appear upon the list, but they are not to be completed until about August, and as they present features quite novel in the history of merchant shipping, we will treat them after the other vessels of the Reserve have been dealt with. Lord Brassey lays down as a law that "exceptional strength and speed are the only desiderata" in this class of vessels. We here beg leave to elaborate these simple conditions roughly into the following:—Structural strength, minute subdivision into water-tight compartments, invulnerability of the vital parts, great stability, so as to offer a steady gun platform, capability of being easily and promptly handled, and a speed that will enable them to outstrip any enemy of a nature too formidable to be fought. Let us, then, examine the vessels under consideration, and see in what degree they comply with the above necessary demands upon them.

We saw a year ago how two of these steamers touched each other in mid-Altantic, with the result that one had her bows torn away, while the other had a huge hole cut in her side between wind and water, and nothing but the noted attention paid to the bulkheads of White Star liners prevented an awful double disaster. We were all startled to hear that the *Oregon*, then on the list, had been run down by a schooner, and it is but natural to ask in what respect the surviving vessels are better than she was. Some of them, in that they are built of steel, do possess a decided advantage over her; but as to subdivision into water-tight compartments, we find that none of them boasts of more than nine bulkheads, while most have but seven or eight. The nine bulkheads of the *Oregon* did not prevent her from foundering. The final plunge was certainly postponed during eight hours, so as to insure the safety of the large number of souls on board, but down she went at last; and if she had been fitted with only so many bulkheads as some others of these cruisers, she would not have floated so long. Next as to the protection of vital parts. We take it that the vital parts of a cruiser would be the rudderhead and steering gear, the boilers and engines and funnel casings, and the conning-tower or wheel-house. To the question as to whether these parts are adequately protected in our merchantmen, the answer is self-evident to every one who in any way understands their construction. The exposed position of the steering gear is in itself an insuperable difficulty, seeing that the rudderhead quadrant is situated from 10 ft. to 20 ft. above the water-line; while it is questionable whether any amount of coal armor would properly preserve the boilers and cylinders, the latter especially being nearly always above the load-line of the vessel.

With regard to the fighting powers of the cruisers, it is a matter of doubt whether these vessels are constructed with sufficiently heavy scantlings to be able to fire with impunity the guns with which they would be fitted, while an attempt to ram an enemy's ship, which would be a very reasonable feat to be expected of a cruiser—given the opportunity—could only be attended by consequences most serious to both parties. We do not ask that these converted mail steamers shall be able to withstand the projectile of a 110-ton gun or the spur of an armor-clad, but we do expect that our commerce protectors shall be capable of using their weapons of offense and defense without accomplishing their own destruction by so doing. The famous vessels on the list are to work wonders, but the authorities put the fact out of mind that the structural strength that experience dictates as necessary to resist the weather of an Atlantic passage is formulated on conditions very different to those of an action. Furthermore, the stability of a passenger liner is calculated so as to produce the easiest possible motion consistent with safety, a quality

which caused the *Oregon*, during the manœuvres in Bantry Bay, to be stigmatized by the naval officers as very crank, and therefore very unsuitable to act as a gun platform. An armed cruiser will simply be a useless incumbrance if she cannot work her guns with some degree of accuracy.

The capability of this class of vessel of being easily and promptly handled is a quality chiefly conspicuous by its absence. It is only natural that a vessel built of a great length in proportion to her breadth, say in the ratio of nine or ten to one, and furnished with only a single propeller, and a rudder none too large, should be deficient in turning power, as compared with a ship of war. The general design of the vessel is calculated for fast ocean steaming straight ahead, and is in no sense fitted for, or capable of, executing such sudden turns and twists as will obtain in an action with an enemy at fairly close quarters; and at close quarters the engagement will have to take place, in anything like a seaway, if either party means to cripple the other. Some people affirm that the stern is the only aspect of the cruiser which need be presented to a foe, in which case speed will take the place of other attributes; but we take it that these merchant cruisers are not subsidized to escape from the first foreigner who appears, but to protect themselves and any vessels of the same flag which may be with them from any enemy short of an ironclad. Our interpretation of a cruiser's functions being correct, it is evident that a slow turning vessel is of little use, for a much smaller and weaker boat, if readily handled, would soon give a good account of its more unwieldy adversary.

Then as to the question of speed, in which these cruisers are supposed to show so marked a superiority over war vessels. The 19 steamers already afloat, and therefore ready for service, average exactly 15¼ knots at sea, according to the official reckoning, varying, as before stated, from 18½ knots down to 14. Where do these figures show a superiority in speed, as compared with the 19 and 20 knots unarmored cruisers of the French and other navies? Supposing one of our converted mail steamers to find herself while in the exercise of her protective duties anywhere within reach of one of these 19 or 20-knot vessels, where is that excess of fleetness necessary to carry her out of range of an adversary with which she is unfitted to cope? Even if we cut down the speed of the foreign cruisers by three knots as an average to be maintained at sea, they still show a knot to the good, as compared with the average of our so-called merchant cruisers. With regard to the two new White Star liners now building, we have already alluded to them as possessing features of interest distinct from and superior to those of the other steamers on the list. These two vessels are of about 10,000 tons gross, measuring 565 ft. in length, by 58 ft. breadth of beam, with twin screws, driven by two interchangeable sets of triple expansion engines. In addition to a good number of transverse bulkheads, there will be longitudinal bulkheads running the entire length of the ships, and extending above the water-line, an innovation of no small importance if the usefulness of the vessels as naval cruisers is to be considered. The steering gear, rudderhead, boilers, and engines are situated below the load water-line, the coal bunkers being placed abreast of the engines as armor. These are the chief points which at present are made known, and, even with this fragmentary specification, it is evident that these vessels mark the commencement of a new era in the history of mail steamers. They are calculated to develop a speed of at least 19 knots, which, however, according to past experience, may be considerably increased upon actual trial, it being highly probable that the late performance of the *Etruria* may be eclipsed most completely by these newcomers. So far as speed and construction go, these vessels may be accepted as fulfilling conditions suitable to their employment as cruisers, the only point against them being their excessive size, a point, however, which may be no disadvantage in actual service, especially if their huge bulk and length does not militate against the increased manœuvring powers afforded by twin screws. As transports, they are each stated to be equal to the task of conveying 2,000 men to Bombay in 14 days *via* the Suez Canal, or 22½ days *via* the Cape in the event of the shorter route being blocked.

Having thus briefly reviewed the more prominent failings of the present fleet of merchant cruisers, failings which should debar many of them from being included in the list, we now venture to submit certain conditions as absolutely requisite in any vessels which are to be intrusted with the responsibility of protecting our commerce. They are not, we consider, conditions of an impossible nature, although they may seem at variance with the present practice of shipbuilding; and we certainly are of the opinion that the Admiralty has no right to subsidize vessels in the future which are not built in accordance with some such regulation. Briefly then, the following represent our idea of what qualities the armed cruisers of the future should possess:

A hull built of steel of large scantling, with the bows especially strengthened so as to be able to ram, if necessary. In order to secure good manœuvring facilities for this purpose, the beam of the vessel should not be less than one-eighth of the length, and the fore-foot and all the deadwood astern should be shaped to this end, while the rudder should be considerably larger than is the rule with the present class of merchant steamers. As to subdivision, there should be a cellular double-bottom extending the whole length of the vessel, at least 15 transverse bulkheads rising to the upper deck, and a longitudinal bulkhead throughout the vessel's length, rising to the same height. No doors should be fitted in the bulkheads at a less distance above the load water-line than 6 ft. The engines and boilers should be placed well below the load-line, with the bunkers arranged so as to afford at least 10 ft. of coal armor against the sides of the ship; and each set of engines, and each set of, say, two boilers, should be placed in separate compartments. The funnels and uptakes and the conning-tower should be efficiently protected by armor-plates. The engines should be twin-screw, of the triple or quadruple-expansion type; and their parts should be interchangeable. The stoke-holes should be arranged for forced draft, but under natural draft the mean sea speed of the vessel should reach at least 19 knots per hour during a 96-hour trial. The supply of coal should enable the vessel to cruise for long periods at 10-knot speed, or for 10 days at 20-knot speed.

These latter considerations of speed and coal endurance stand pre-eminent among the requirements of an armed cruiser, and are the qualities which above all should be insisted upon before any steamer is subsidized in the future. How far it is possible to reconcile these conditions with those governing at present the construction of our great mercantile ships is a question on which we shall not enter.

NOTES ON STEAM HAMMERS.

BY C. CHOMIENNE, ENGINEER.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 356.)

CHAPTER XIII.

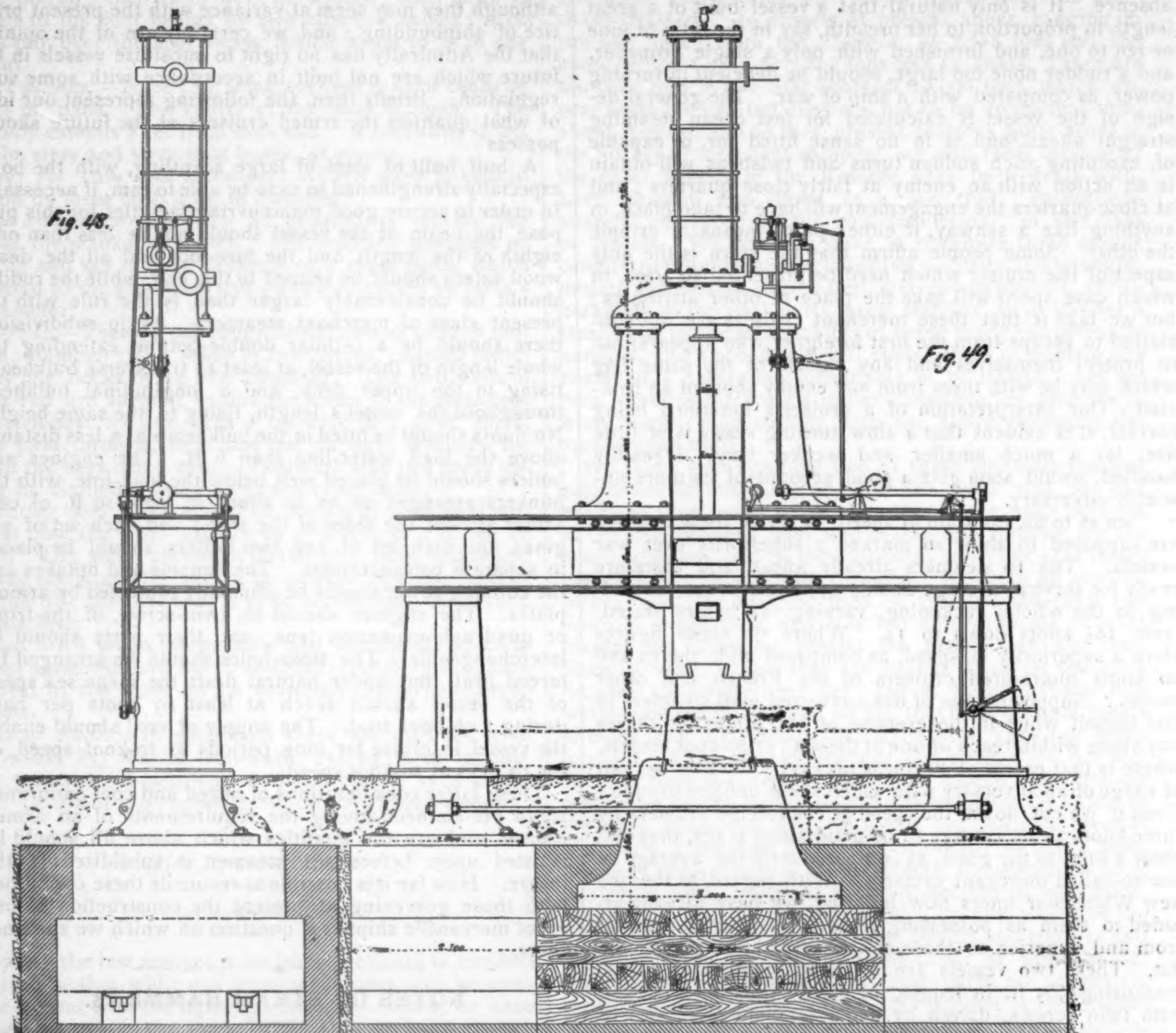
THE HAMMER.

THE form of the hammer should be as simple as possible; it depends exclusively upon its weight, its breadth, and the form of shoe or die which it must carry. Its height must be great enough to permit it to be guided properly at the moment of the blow, for the reaction of the hammer upon the guides often lead to a rupture of the frame, and this is another reason which makes it necessary to brace these frames strongly at that point. From this fact it also results that for the same play between the slides the inclination of the hammer in relation to the rod is less where the height is great, and consequently the rod is less subject to breakage.

Hammer-blocks are generally of cast iron or steel; a few are of forged steel or of wrought iron. Their form is usually a parallelopipedon. In cast-iron hammer-blocks there is often made above the key-way a recess intended to receive a wrought-iron ring, which is sprung on for the purpose of strengthening the head and preventing breakage.

The dovetails by which the faces of the hammer and the anvil are held on should be at right angles in every case where the frame is open at the bottom, in order to avoid the loosening of the shoes or dies, to hold them well opposite each other, and to do away with the risk of a glancing blow.

usually that shown by fig. 46; sometimes, however, they are given the form shown in No. 2, fig. 46, especially in the case of hammers with wrought-iron frames (as, for example, the 100-ton Terni hammer), in order that the slides bolted to the legs, which are generally of wrought-iron



SINGLE-ACTING 5-TON HAMMER, FIVES-LILLE COMPANY.

Where the frame is single or not open at the bottom, these dovetails are necessarily in line with each other, because it would be impossible to drive keys for them otherwise.

The form of the hammer-block and the guides on it is

plates and angles, may be made of as simple form as possible. The form No. 1 is the best, because it presents greater resistance and gives the hammer-block the greatest possible width, which is always a great advantage, as will be readily seen.

CHAPTER XIV.

HOLDING DOGS OR CATCHES.

All heavy hammers should be provided with holding dogs or catches, intended to keep the hammer in position when any one is working below, and especially when the shoes or dies are being changed ; this arrangement insures

No. 1. No. 2. Fig. 46.

complete safety to the machinist charged with the work below, and also saves steam, as it prevents leakage through the piston when the changes take some time.

Catches working vertically seem to me to fulfill their object much better than those working horizontally, considering the ease with which they can be operated ; moreover, the strain upon them is that of compression and not a transverse strain.

In the 10-ton or smaller hammers a single catch is usually sufficient ; beyond that weight it is better to employ two, which are held together by cranks so that they can be worked at the same time.

These catches should be so arranged that the hammerman may be able to work them, by means of a foot-lever or a hand-lever. For large hammers the foot-lever is preferable because it leaves both the hammerman's hands free to work the valves, and moreover there is not likely to be any confusion in working the levers.

The catch is fixed upon a horizontal shaft or axis, which is moved by an intermediate lever receiving its motion from

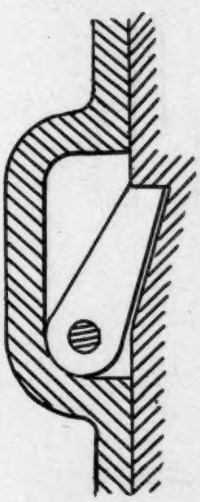


Fig. 47.

the foot-lever by means of a crank. The lower extremity of the catch should be concentric with the shaft and should fit well in the casting in which it is set, in order that the shaft may not be subjected to transverse strains. Under these conditions the catch alone does all the work and transmits the strain to the frame, the shaft serving only to cause it to move. A sketch of this arrangement is shown in fig. 47.

CHAPTER XV.

GENERAL REMARKS.

We have always considered it best to recommend the use of mineral oil for lubricating the pistons instead of tallow. The oil should be allowed to vaporize, or lubricate the steam, before its entrance into the valves. This method of lubrication is much more economical than tallow and also much more rational, because it is constant instead of intermittent.

We would also recommend the use of automatic escape valves placed immediately before the valve or the steam-port in order to free the steam from the water of condensation, which generally forms in considerable quantities in consequence of the irregular work of these tools.

In all large hammers it is necessary to place, at a certain height above the cylinder, two girders long enough to span the hammer completely and carrying a rolling crane. This crane will be found of great service not only in setting up a hammer, but also because it will enable a broken piston-rod to be replaced, or other repairs to be made, in case of accidents, more easily and quickly than without it. The crane known as the Mégy fulfills admirably the requirements for this purpose, and one can easily be made to serve several hammers if they stand in a line.

In steam hammers most of the parts are subjected to shocks, the intensity of which cannot be appreciated or exactly calculated beforehand, and for that reason, in designing a hammer, careful attention should be paid to what has already been done in this line, and the engineer should confine himself within the limits approved by experience.

CHAPTER XVI.

THE FIVES-LILLE FIVE-TON HAMMER.

The hammer represented in figs. 48, 49, and 50 is one made in 1885 by the Fives-Lille Company for the National Marine forges at Guerigny. Fig. 48 is a side elevation ; fig. 49 a front elevation, and fig. 50 a plan.

This is a single-acting hammer with an independent anvil-block ; it is of a construction as yet little used in France, but is remarkable for its good design. The proper proportions have been well observed in each of its parts, and they are the result of careful study.

We will not describe the foundations, for the drawing shows sufficiently well the care with which they have been made, in order to secure great stability for this tool.

The frame is composed of circular columns of wrought iron supporting a square box-girder of wrought-iron plates and angle-bars, upon which are placed the guides and which has in the center an opening just large enough to permit the passage of the hammer.

The guides are of cast iron and are fixed to the girder by heavy bolts ; they are united at the upper end by the upper frame or table, which serves at the same time as a cross-brace to stiffen them.

On this upper frame rests the cylinder, to which is bolted at the lower end a steam-chest, the steam-valve being in front of the steam-chest. The distribution of steam is made by balanced valves with a double seat.

The hammerman is placed behind the columns on a level with the ground and has to move by levers :

1, The steam admission valves,
2, The balance valves,
3, The safety catch or dog.

The distance between the centers of the upright columns being 6 meters and the cross-girder being 2 meters above the ground, the anvil has abundant clear space around it, so that the forgings can be handled with much facility.

The principal dimensions of this hammer are as follows :

Weight of the working parts...	5,000	kilos.
Weight of the anvil-block.....	35,000	kilos.
Stroke of the hammer.........	2.000	meters.
Width of the hammer-block...	0.800	meter.
Diameter of the steam cylinder.	0.600	meter.
Diameter of the piston rod....	0.150	meter.

This tool answers very well for large forgings, such as stem and stern-posts, ship rudders, ship anchors, etc., and has thus far given excellent results.

CHAPTER XVII.

THE L'HORME TEN-TON HAMMER.

This single-acting hammer, shown in figs. 51, 52, and 53, was designed by the Compagnie des Forges de l'Horme for the Firminy Steel Works. It has many advantages which a hammer intended to forge heavy pieces should have. Fig. 51 is a side elevation ; fig. 52 a front elevation, and fig. 53 a plan of this hammer.

The anvil, which is of unusual weight, 80 tons, has a very wide base. It is made in two parts, held together by means of four hoops, put on hot over hubs or lugs cast on the block. Between the two parts is a round block embedded or mortised into each piece one-half of its thickness, which is intended not only to cause the pieces to come together properly, but also to prevent any sliding of the

upper part upon the lower and to make them, as far as possible, as solid as if cast in one piece.

The upright frames or pillars are of **I** section, with proportions carefully worked out, and present a very great resistance to shocks. At the lower end they are divided into two parts, leaving between them a clear space of 1.500 to 1.800 meters in order to permit the proper handling of the forging under treatment.

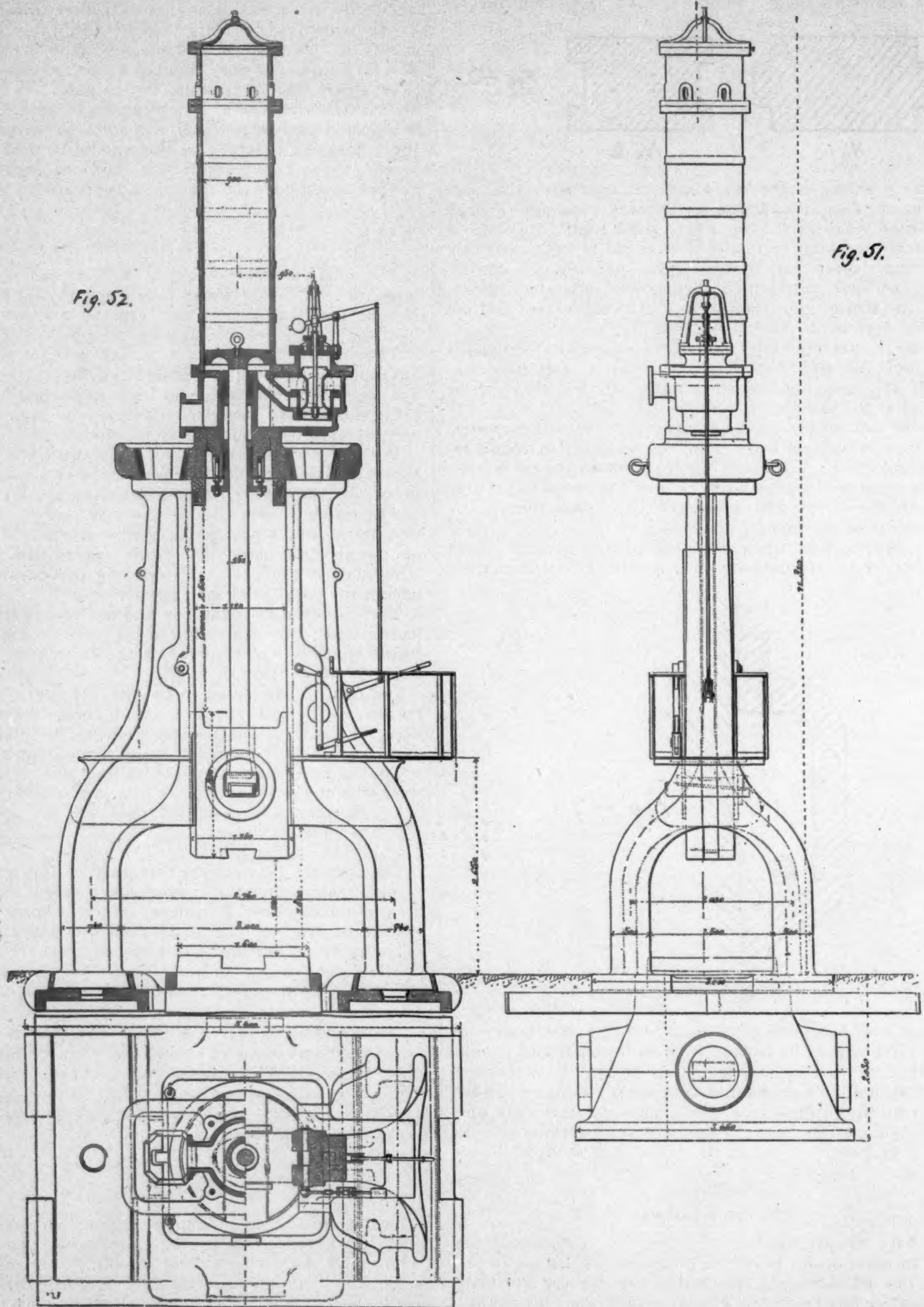


Fig. 53.

SINGLE-ACTING 10-TON HAMMER, COMPAGNIE DE L'HORME.

The width of their base is 3.000 meters and the open height below the guides 1.800 meters, so that it will be seen that the forging will be very accessible and consequently easily handled.

The pillars are keyed below to the cast-iron bed-plates on which they rest, and are centered upon those by pins cast in them. They are fixed above to the upper frame or table by keys made of heavy wooden blocks, which are

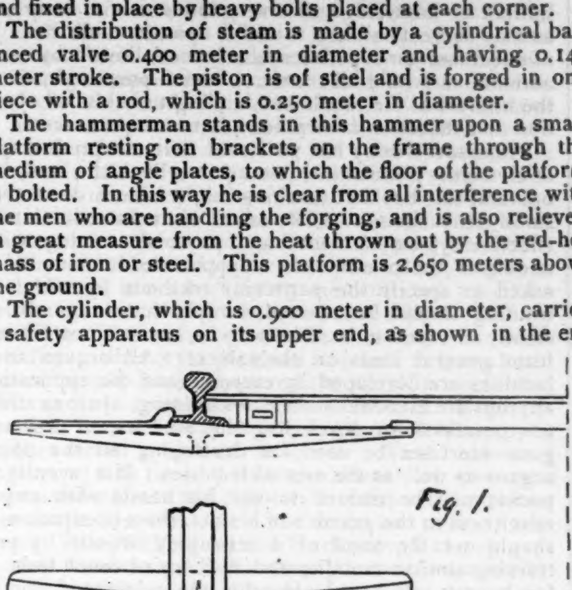
used in order to take up in part the shocks to the hammer.

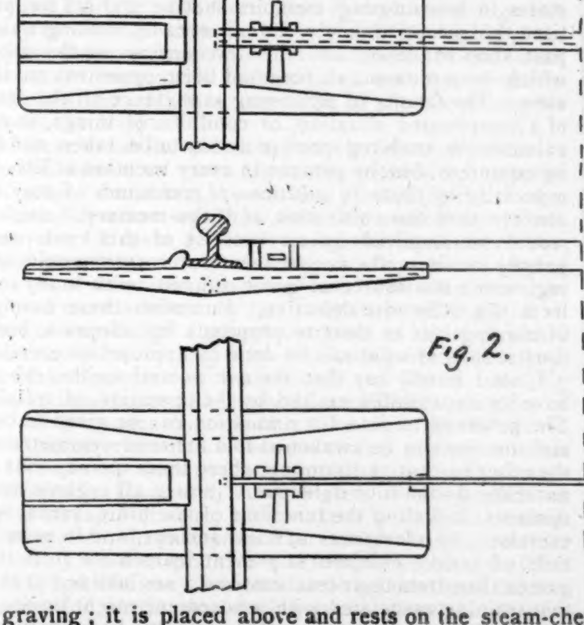
The bed-plates on which the frame rests have a very large base, and are joined together inside and outside by small iron rings put on hot upon hubs cast on the face of the plate. They are set upon a large foundation of masonry and fixed in place by heavy bolts placed at each corner.

The distribution of steam is made by a cylindrical balanced valve 0.400 meter in diameter and having 0.140 meter stroke. The piston is of steel and is forged in one piece with a rod, which is 0.250 meter in diameter.

The hammerman stands in this hammer upon a small platform resting on brackets on the frame through the medium of angle plates, to which the floor of the platform is bolted. In this way he is clear from all interference with the men who are handling the forging, and is also relieved in great measure from the heat thrown out by the red-hot mass of iron or steel. This platform is 2.650 meters above the ground.

The cylinder, which is 0.900 meter in diameter, carries a safety apparatus on its upper end, as shown in the engraving; it is placed above and rests on the steam-chest, being fastened to it by bolts.





The steam-chest is made in one piece with the frame, but rests in the center on a cylindrical ring carefully finished and fitted, and is secured to the upper frame by four large bolts.

The hammer carries a safety catch which can be worked by the hammerman from his platform by a foot lever.

The dimensions of this hammer are as follows:

Diameter of the steam cylinder...0.900 meter.
Stroke of the hammer..........2.500 meter.
Diameter of the piston-rod.......0.250 meter.
Diameter of the piston-valve.....0.400 meter.
Stroke of the piston-valve.........0.140 meter.
Weight of the working parts..... 10 tons.
Weight of the anvil-block........ 80 tons.

The large free space given below, the long stroke of the hammer, the great stability of the frames, their great resistance to shocks, the elegance of their shape, the simplicity of the distribution of steam, the great weight of the anvil-block and its wide base enable us to say that this hammer is an excellent example of a tool of this class, and may be safely taken as a model for hammers intended for heavy forging.

(TO BE CONTINUED.)

An Indian Cast-Iron Tie.

THE accompanying illustrations, from *Indian Engineering*, show a cast-iron railroad tie, designed by G. E. Moore, Deputy Consulting Engineer to the Indian Government. Mr. Moore says that experience has shown that steel ties are not suited for India, especially for the damp climate of Bengal, where they rapidly corrode on the seat under the rail, and are then useless even for scrap. Cast-iron ties have shown much greater endurance, but the drawback in using those heretofore designed has been the number of parts and the high first cost. The cast-iron pot-tie which has been used on some Indian lines is bad, as it does not give an equal bearing on the ballast, and it is also a very inconvenient form to load and ship.

The illustrations, figs. 1 and 2, both show a form of tie designed for use with a rail section similar to that ordinarily used in this country, the only difference being in the tie-bar connecting the two sleepers, which in fig. 1 is a T-iron bar and in fig. 2 a plain bar. Each figure shows only one casting and one-half the tie-bar, the other end of the tie being exactly similar to that shown.

The operation of laying the ties is very simple, the cast-iron plates being inserted under the rail, the tie-bar placed in its seat, and the keys driven home. The gauge depends, not, as in other cast-iron ties, on the accuracy of the casting, but upon the length of the tie-bar.

The advantages claimed by Mr. Moore for his design are that there are few parts; that the cast plates are cheap and easily made, one pattern only being required; that the tie will last long, being of a simple and strong form; that the tie-bar being above the plate and not buried under the ballast, it will not rust fast in the socket; that each tie-bar is in fact a track-gauge, thus securing the accurate position of the rails; that the rail resting directly on the plate, the track will be steadier and easier to maintain, and that when renewals are required the old ties can be taken out and new ties put in easily and quickly.

The Vague Cry for Technical Education.

(Lord Armstrong, in the *Nineteenth Century*.)

THERE is at the present time a great outcry for technical education, although few people have any distinct idea of what they mean when they use that term, or any definite opinion either as to the class of persons who will be chiefly benefited by it, or as to the time of life at which it ought to be acquired. Additional zest has been given to this subject by the meeting lately held at the Mansion House respecting the scheme for establishing polytechnic institutes in London, and the present is therefore a fitting time for bringing forward ideas which have long been incubating in my mind, and which, I believe, are in accord with those of many employers of labor who, like myself, are engaged in manufacturing pursuits in which technical requirements afford most scope for application.

I have no adverse criticism to make on the speeches delivered at the Mansion House meeting, except that I think them rather vague and indefinite, as speeches on technical education generally are. Very admirable sentiments were expressed by Lord Salisbury and others on the objects sought to be attained, but there seemed to be considerable discordance of view on the part of the speakers as to what those objects should be. Lord Salisbury cautiously adopted the term secondary education instead of technical education, meaning by the former term the education which is to follow school education, and thereby using a more comprehensive phrase and avoiding the troublesome but not unnecessary task of framing a correct definition. He also spoke of this secondary education as a carrying on of primary education, but he ignored the question whether the existing system of primary education is worthy of being

followed up on its present lines, or whether it requires to be altered to make it more in harmony with the proposed secondary stage. Lord Salisbury most truly said that the first necessity of man is to live, that his first duty is to work, and that the first object of education is to fit him for work; but much as I applaud these words I doubt whether I am in unison with his lordship as to the kind of education which would best fulfill the object he thus enunciates.

In expressing my own views on popular education I must address myself, in the first place, to the present system of primary or elementary education, which is now very generally considered to be ill-adapted as a preparation for the business of life. That system has, in my opinion, the radical defect of aiming at instruction in knowledge rather than the training of the faculties. A man's success in life depends incomparably more upon his capacities for useful action than upon his acquirements in knowledge, and the education of the young should therefore be directed to the development of faculties and valuable qualities rather than to the acquisition of knowledge, which may be deferred to more mature age. Not only should the mind be trained in habits of thought and in quickness and accuracy of perception, but the hand, the eye, and the ear should all participate in training exercises calculated to make these organs more available as instruments of the mind. Nor should the development of the physique be neglected, for, with the great majority of both men and women, personal vigor and activity are the foremost factors in making a living. Except in teaching the art of writing—which, as a rule, is very imperfectly done in elementary schools—no attempt is at present made to educate the hand. The addition of drawing would be a step in the right direction, and would afford a useful accomplishment, but would not supply all that is needed for giving dexterity to the hand. Appropriate exercises ought to be devised for cultivating its mobility, precision, and delicacy of touch; and if, in so doing, the ability to use simple tools were acquired, it would be advantageous in any line of life that might be ultimately adopted. Every man and woman would be the better for pre-acquired manual dexterity, but to attempt to teach children special trades and processes of manufacture would, I conceive, be a mistake. It would involve great expense, would be a misapplication of time, and would only forestall the more effectual teaching which at a more suitable age may be attained by actual practice in factories and workshops. As to the thinking faculties, they are to a certain extent at present exercised in learning arithmetic, but it would be better if this were done more by reasoning than by rule. The late Mr. Bidder, who as a youth was called the calculating boy, used to say that he never learned a rule of arithmetic in his life, but taught himself to comprehend the relations of numbers to each other and the result of their combinations by handling groups of peas in such a manner as to visualize a system of arithmetic which his mind could grasp with perfect distinctness. It is by methods such as this rather than by books and rules that the minds of children should be led on to the forming of clear ideas and to the exercise of reasoning power. A rule may be committed to memory for convenience of use, but the first object should be to make the learners understand, as far as possible, the reasons upon which the rule is founded. But the present system of elementary education does little else than burden the memory with facts, rules, and information, which for the most part are of little use for developing the intellect, or preparing it for the ordinary vocations of life. Such instruction excites little interest in the minds of the pupils, and in the vast majority of cases is speedily forgotten. Even in the case of the few youthful minds that appreciate knowledge as thus learned and display superiority in acquiring it, the effects are by no means invariably beneficial, seeing that such superiority tends to create a fastidiousness which makes manual labor distasteful. Successful scholars, if boys, generally think themselves too good for mechanical work, and aspire to be clerks or teachers, and, if girls, they shun domestic service, and aim at employment as shopwomen, telegraph operators, and so forth. Thus the *élite* of the popular schools seldom engage in manual labor, and when they do, their school acquirements are not conducive either to efficiency or contentment.

The teaching of reading, writing, drawing, and arithmetic are all distinct from instruction in knowledge. They are means to an end, and are necessary both to the attainment of knowledge and to its utilization. I do not mean to say that the inculcation of knowledge should be wholly excluded from popular schools, but I think it should be limited to knowledge of a very fundamental nature, such as may serve as a basis to build upon in adult life. Juvenile lectures on experimental science followed by easy examinations would also serve a useful purpose by exciting the interest of the pupils and leading to habits of observation and reflection favorable to future acquirements.

Professor Huxley has well said that our present system of elementary education is much too bookish; and, in my opinion, this bookish teaching might be cut down to very small dimensions, so as to admit of the introduction of an effective system of mental and physical training, without adding to the present cost of popular education. If I am asked to specify the particular methods by which such training should be effected, I reply that I am not sufficiently an expert to be able to do so, but it is not difficult to form general ideas on the subject. All organs and all faculties are developed by exercise, and the application of appropriate exercises constitutes training. Just as athletics are practised for developing the muscles, so may analogous exercises be used for developing all the physical organs as well as the mental faculties. If a juvenile pickpocket can be trained to use his hands with exquisite adroitness in the practice of his nefarious occupation, why should not the hand of a schoolboy acquire by proper training similar mobility and delicacy of touch to be used for honest purposes? Houdin, the celebrated conjurer, states in his amusing memoirs that he and his son practised the receptive power of their eyes by walking quickly past shop-windows, and then recounting all the objects which in a moment of time had been presented to their view. The faculty of perceiving at a glance all the details of a complicated situation, or condition of things, is most valuable in enabling prompt action to be taken not only by conjurers, but by persons in every vocation of life, and especially by those in positions of command. I may also observe that the cultivation of "eye-memory," such as would be acquired by an exercise of this kind, would greatly facilitate the acquirements of correctness in spelling, which is a source of great difficulty with many intellects not otherwise defective. I mention these examples of training not as definite proposals for adoption, but as illustrations of what can be done by appropriate exercises.

I need hardly say that the ear as well as the eye can have its capabilities exalted by the operation of training. The power of minute discrimination can be given to both, and the one can be awakened to a sense of symmetry and the other to that of harmony where those perceptions are naturally dormant or defective. In fact, all organic developments, including the functions of the brain, turns upon exercise. In cleverness of hand and eye, and in promptitude of action, children at present learn more from their games than from their teachers, and I am inclined to think that training associated with amusement might be so systematized as to produce excellent results, both in mental and bodily development, as well as in the promotion of health and vigor; but in relation to these I may observe that a sufficiency of food and clothing is especially necessary. Indeed, the want of it in the children of poverty-stricken parents is already a serious difficulty in popular education.

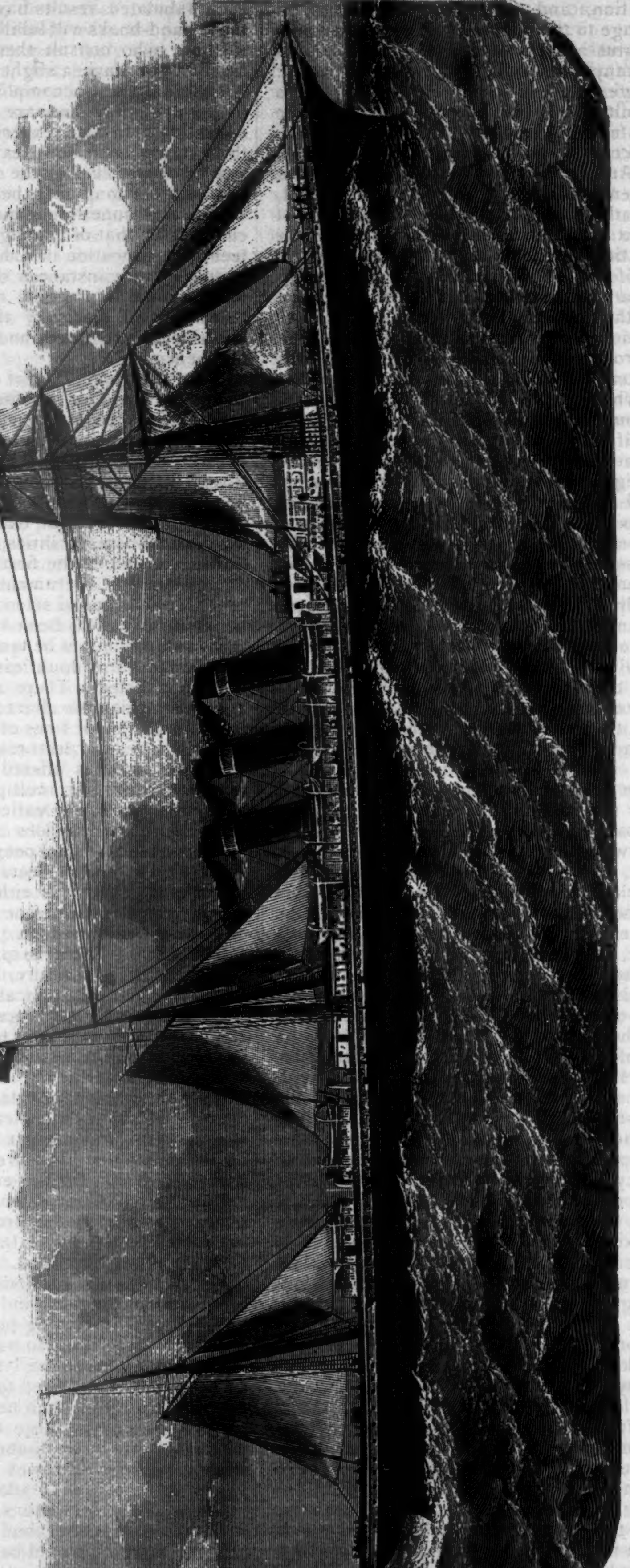
It is related by Sir Frederick Pollock, in his interesting reminiscences, that when he was at the University of Cambridge one of the subjects submitted for discussion at a debating club was the question, "What is the use of useful knowledge?" We are not informed what was the result of the debate, nor is it important that we should be so; but the question appears to me to present in a quaint form a theme of a very debatable nature. I think it must be conceded that where a man fails to get on in the world it is not from want of knowledge so much as from want of natural capacity, and of zeal, energy, and perseverance. If he possess natural capacity, combined with these qualities, he will surmount all difficulties in attaining it. If there be capable men striving after knowledge necessary to their advancement and unable to obtain it, they have not come

within my observation, and as to the incapables, it would be no advantage to them if they had it. Many people imagine that genius is kept down from want of knowledge, and that in many cases it is thus lost to the world. This I entirely dispute. Genius is irrepressible, and revels in overcoming difficulties. Except in what are called the learned professions, few men who have risen to distinction have owed their success to book knowledge thrust upon them in early life. Among engineers I may instance James Watt, George Stephenson, Smeaton, Brinley, and Telford, as men who have made a great mark in the world, some of them a transcendent mark, and yet none of them were loaded with information at school, but were left to educate themselves in after life, with scant facilities, in such knowledge as was necessary to the exercise of their talents and the attainment of their ends. Their receptive faculties might have been quickened by early cramming ; but their originality would probably have been impaired, and their natural talents, instead of being concentrated upon the line of thought for which they were best fitted, would have lost effect by diffusion in unprofitable channels. The well-known dictum that if the Romans had had to learn Latin they never would have conquered the world, is suggestive of what our loss might have been if these self-made engineers had frittered away their energies upon inappropriate studies forced upon them at school. What I have said of engineers may be said with equal truth of men who have attained success and reputation in the various phases of mercantile life, and also in the naval and military professions. Take Wellington and Marlborough among generals, and Nelson and Blake among naval commanders. Surely none of these would have directed the armies and navies of England with more effect if book knowledge had been crammed into them at school, and it is highly probable that their services would have been lost to the nation if success in competitive examinations, such as are now in vogue, had been made a condition of their entering the Army or the Navy.

If I were to ask the question, For what class of persons is technical education more especially required ? I suppose most people would say, the working classes ; but I think a little consideration will show that this answer would not be correct. It must, I conceive, at once be admitted that in the numerous class of laborers figuratively styled "hewers of wood and drawers of water" no man would be rendered more efficient by the possession of any kind of technical knowledge, although the value of his labor would undoubtedly be enhanced by his having been, as a boy, trained in the exercise of his hands and limbs. Making one step in advance of the wholly unskilled laborer, let us take, for example, the case of a "hewer of wood" in the more special sense of a woodman skilled in the use of his axe. To do his work properly would require skill, though of a humble kind, and some degree of intelligence, as well as strength of arm ; but it cannot be said that technical education, distinct from that which he acquires for himself by his own practice and experience, would add to his skill and efficiency, whether he be an unlettered laborer working for wages, or a distinguished statesman practising as an amateur. Ascending a step higher in the scale of labor, we may take the case of artificers, such as joiners, carpenters, fitters, and all others who work in wood and iron for constructive purposes. Here again we find manual skill, intelligently used, the chief criterion of the value of their labor. These men in general work under direction, and so long as they do so, it is their manual skill, and not their knowledge, that comes into play. It is, therefore, not easy to see how knowledge distinct from manual skill can add to the value of their labor. As to those whose office it is to direct such labor, they are men chosen for their superior intelligence as well as skill to act as foremen, and whose duty requires them to work more with their brain than with their hands. They, in fact, are persons who emerge from the class of manual workers, and it is here where the value of technical knowledge first comes in. But even in their case all the information they required can be found in a condensed and tabulated form in hand-books applicable to all kinds of constructive art. Such technical information is in this form available to every man who can read and do arithmetic, however ignorant he may be of the scientific methods by which such tabulated results have been arrived at. No doubt these hand-books will fulfill their purpose more completely if those who consult them can work simple algebraic formulas or have a slight acquaintance with geometry ; but these limited accomplishments can easily be acquired by private study, and are quite within the reach of self-education. In fact, experience shows that it is men of this stamp who, on leaving school, have voluntarily availed themselves of the facilities offered for self-education in order to qualify themselves for positions of responsibility and superintendence. The next class we have to consider is that of managers and designers, who require technical education in a higher degree ; but even here it is only in rare instances that high attainments in science are essential to practical results. It is only in pursuit of research and discovery that highly advanced scientific knowledge is required, and not even then in all branches of science.

Upon the whole, I am of opinion that the number of persons who would be benefited in business by scientific education of a technical nature, and who have the zeal, capacity, and perseverance necessary to its attainment, constitutes a very small proportion of the population, and it remains to be considered whether the existing facilities for the voluntary acquisition of technical knowledge are sufficient, or to what extent they require to be supplemented. These facilities, as they are found in large towns, consist, in the first place, of evening classes conducted under Government auspices for the teaching of practical and applied science. If knowledge for clerkships be wanted, such as book-keeping and short-hand writing, those subjects might be taught at a small expense in a similar manner, and doubtless would be so if a desire for it were manifested. There are also various associations of a general scientific character, and others specially applicable to particular lines of business, at which institutions papers are read or lectures given on appropriate subjects, and other facilities offered for self-education. These associations might be multiplied to any extent and be made applicable to every variety of business, and I believe their multiplication does actually keep pace with the demand for them. The people have also the advantage of university extension lectures, and they have access to abundance of libraries either absolutely free or belonging to mechanics' institutes or scientific societies to which any one can be admitted on payment of a very small annual subscription. There is also the universal advantage of cheap scientific literature, including books of reference of a technical nature applicable to almost every kind of employment on which science can be brought to bear. The chief want appears to me to be that of public laboratories, to which qualified students could be admitted for the practice of experimental science. To these laboratories class-rooms should be attached for evening teaching. As to colleges of physical science, they are apt, I think, to be too scholastic for popular requirements, though valuable for the cultivation of theoretical science of a more abstract nature, and also for the education of those who have to become teachers of science. These colleges could be made to embrace more practical instruction than they do, but such instruction is attainable at a smaller cost by the means I have described. When colleges can be established by public subscription or private munificence, they are worthy of approval and commendation ; but where the State or local governing bodies have to furnish money for education in relation to national industry, they must look to attaining the required results at the least possible expense, and I am inclined to look upon colleges as luxuries in education rather than necessaries.

But it is only in large towns that the facilities I have mentioned are to be found, and it would certainly be desirable that small towns and rural districts should be placed in a position to afford practical scientific instruction to all capable persons who earnestly seek to attain it. In rural districts the chief occupation is agriculture, the practice of which would be benefited by technical instruction which is not at present provided. Great ignorance prevails in the practice of this important industry, but there does not appear to be much desire for enlightenment among the farming population, for in the few cases where night schools have been established for useful in-



THE INMAN LINE STEAMER, "CITY OF NEW YORK."
BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

struction relative to farming, the attendance has been very unsatisfactory.

As to the question whether our commerce is to be saved from the effects of foreign competition by a wide diffusion of technical knowledge, I have no faith in any such safeguard. Cheapness of production and superiority of quality will decide the victory in the race of competition, and if by early training we develop the mental and bodily faculties of our people, we shall improve our chance of maintaining a foremost place; but not, I think, by any forced or indiscriminate system of imparting knowledge. I do not undervalue technical knowledge voluntarily acquired as a means to an end, but it is the brain-workers and not the hand-workers who will seek to attain it and benefit by it. Compulsory education is neither justifiable nor practicable except in childhood, and without compulsion I am satisfied that it is only individuals of superior intellect and fitness for business that would perseveringly avail themselves of new educational facilities. Such new facilities should await the demand for them, and be supplied gradually and tentatively, for it would be folly to rush into new and costly projects without any certainty of their resulting in adequate benefit. I most heartily concur in Professor Huxley's commendation of the great services rendered by the Science and Art Department in the promotion of evening classes for the teaching of art and practical science; and if Government intervention be needed in other branches of technical knowledge, I think it would be wise merely to expand in the same economical and unpretentious line of action.

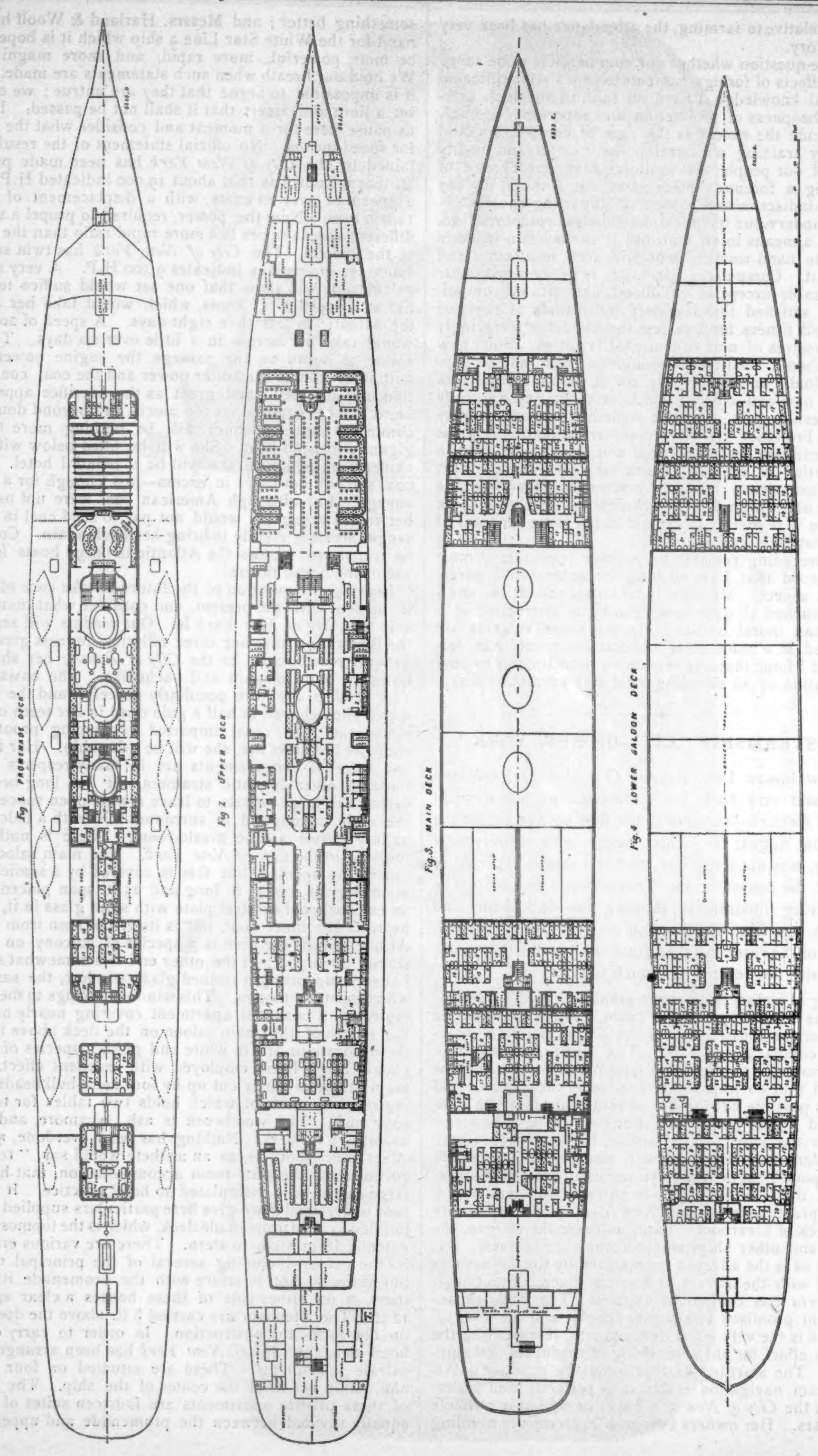
In the preceding remarks on popular education it must be understood that I am viewing the subject in a purely utilitarian aspect. My topic is technical education, and I leave untouched all questions relating to instruction of a religious and moral nature. Happily those subjects are now treated in a much more conciliatory spirit than formerly, and I hope that any remaining impediments to popular education of an elevating kind may eventually disappear.

THE STEAMSHIP "CITY OF NEW YORK."

THE new Inman Line steamer *City of New York*—the largest vessel ever built for commercial purposes except the *Great Eastern*—completed her first voyage across the Atlantic on August 10. This voyage, with entirely new machinery, was not a test one, and the ship is expected to be one of the fastest in the Transatlantic service. The accompanying illustrations, showing the deck plans and the engine, are from the London *Engineering*; the general view of the vessel is taken from the London *Engineer*, together with the description which follows:

Nothing in history is more remarkable than the development of the Atlantic passenger trade. For a considerable period after the construction of the *Great Western*, progress was comparatively slow. The *Persia*, launched in 1851, represented finality for a long period, and it may be safely said that no important advance on the *Persia* could have been possible but for the advent of the surface condenser and higher pressures. For even though the screw had taken the place of the paddle, the gain would have been moderate so long as low pressures were retained. The compound engine rendered another great stride possible, and the *Alaska* began to show shipowners that it might be practicable to place New York within little more than a week of Liverpool. Later on came the *Oregon*, the *Etruria*, and other ships whose names are famous. But enormous as is the advance represented by the *Etruria* as compared with the *Persia*, it has not given contentment. The *Etruria* has compound engines. The triple-expansion system promised still higher speeds, and the *City of New York* is the very latest development, representing the maximum effort for the time being of engineers and shipbuilders. The startling feature about the practice of Atlantic steam navigation is that it is perfectly well understood that the *City of New York* will be probably obsolete in five years. Her owners even now contemplate building something better; and Messrs. Harland & Woolf have in hand for the White Star Line a ship which it is hoped will be more powerful, more rapid, and more magnificent. We hold our breath when such statements are made. But it is impossible to argue that they are untrue; we cannot set a limit and assert that it shall not be passed. But let us pause here for a moment and consider what the desire for speed means. No official statement of the results obtained by the *City of New York* has been made public; all that is known is that about 19,000 indicated H.P. gave a speed of over 20 knots, with a displacement of about 12,000 tons. Now the power required to propel a ship at different speeds varies in a more rapid ratio than the cubes of the speeds. The *City of New York* has twin screws. Each set of engines indicates 9,500 H.P. A very simple calculation will show that one set would suffice to drive her at a speed of 17 knots, which would take her across the Atlantic in less than eight days. A speed of 20 knots would take her across in a little over six days. To save about 36 hours on the passage, the engine power, and with it of course the boiler power and the coal consumption, are doubled; and great as the sacrifice appears to be, it is not regarded as too much, and beyond doubt the coming Atlantic steamer will be nothing more than a gigantic torpedo boat. She will be filled below with machinery, while above she will be a palatial hotel. Even coal she will not carry in excess—just enough for a single voyage. For although American coal were not used on her return voyage, it would not pay to send coal in a passenger steamer merely to bring her back again. Coal will be transferred across the Atlantic in cargo boats for the use of the ocean racers.

Leaving the question of the future to take care of itself, let us deal with the present, and consider what manner of ship the *City of New York* is. Our readers will see from the illustration that her three elliptical funnels give her a general resemblance to the *City of Rome*; her shape is, however, more elegant and yacht-like. The bows of the *City of New York* are peculiarly graceful, and the way in which she behaved in half a gale dead in her teeth coming round the Irish coast imparted convincing proof that, sharp as her bows are, she will be a dry ship. Her fittings and internal arrangements are in many respects unlike those of other Atlantic steamers. It has long been the practice in large vessels to leave a wide open space above the main saloon, and to surround this with a balcony or gallery known as the music-room. There is nothing of the kind in the *City of New York*. The main saloon has, indeed, an opening, but this is covered by a semicircular stained glass roof 33 ft. long and 25 ft. span placed inside an external roof of steel plate with stout glass in it, which protects the inner roof, but is itself not seen from below. At one end of the arch is a species of balcony on which stands an organ; at the other end is a somewhat similar balcony supporting a stained-glass window, the sashes of which open on hinges. This window belongs to the drawing-room, a beautiful apartment covering nearly one-half the length of the main saloon on the deck above it. All the decorations are in white and gold, a species of elastic plaster being freely employed with excellent effect. The main saloon is partly cut up by four semi-bulkheads forming recesses, each of which holds two tables for ten persons each. The woodwork is ash, sycamore, and other decorative timbers. Nothing has been overdone, and the effect throughout is, as an æsthete would say, "restful." As concerns the state-room accommodation, that has to a large extent been assimilated to hotel practice. It will be best understood if we give here particulars supplied by her builders. The promenade deck, which is the topmost of all, extends from stem to stern. There are various erections in the center, including several of the principal rooms; but these do not interfere with the promenade itself, as there is on either side of these houses a clear space of 18 ft. The lifeboats are carried 8 ft. above the deck, and do not form any obstruction. In order to carry out the hotel idea, the *City of New York* has been arranged with private apartments. These are situated on four decks, and within 155 ft. of the center of the ship. The largest of these private apartments are fourteen suites of rooms equally divided between the promenade and upper deck.



THE INMAN LINE STEAMER, "CITY OF NEW YORK."—DECK PLANS.
BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

Arrangements are made for having food served in these rooms, and passengers may invite fellow-travelers to their own cabins and entertain them there. Adjoining the parlors are private bath-rooms, and there are also 25 day sitting-rooms for first-class passengers. A novel arrangement consists in the fact that if the rooms are required for sleeping accommodation beds can easily be improvised. State rooms are provided besides on the main and lower decks in the center of the ship for 479 first-class passengers. These rooms are admirably decorated, and the ventilation is complete. The first-class smoking-room is situated on the upper deck at the after-end. It is 45 ft. long and 27 ft. broad, and will seat 130 gentlemen. In this commodious room, which is beautifully fitted up, there is a large bar from which passengers can be supplied with all kinds of refreshments. The second-class dining-saloon is situated aft on the upper deck, and is 27 ft. long and 40 ft. wide, capable of accommodating 150. There are also 96 state-rooms for 390 second-class passengers situated in the after-end of the main and lower saloon decks. The emigrants have fine, airy rooms provided for them at the two extreme ends of the lower main decks. The sleeping berths are in the middle line of the ship, and not, as is usual, built up on the side of the hull, and here the ventilation is also of the best, with Broadfoot's special deck and side ventilators. The *City of New York* is the largest passenger-carrying vessel now afloat. She is 2,50, tons larger than the *Servia*, 2,723 tons larger than the *Etruria*, and 2,340 larger than the *City of Rome*. She is 565 ft. long over all, 63¼ ft. broad, 42 ft. deep—moulded—and 10,500 gross tons, with accommodation for fully 2,000 passengers. She is fitted with five decks, and the space between four of them is 8 ft., but between the upper and main decks is 9 ft. 4 in., while the depth of the hold is 39½ ft. To give an adequate idea of the height of the *City of New York* it is as well to mention that from the keel to the captain's bridge is 76 ft. The hull is all double butt-strapped for strength. The effect is not pleasing, and it is open to doubt whether or not the straps augment her resistance. Below the water-line it ought to be possible to bring her to a smooth surface with cement.

In order to avert rolling, the ship has been fitted with a steadying tank. This is a chamber containing water, placed athwartships, and is intended to arrest or check rolling by the transfer of the water from one side of the ship to the other, at such velocities as will modify her own periodic or rolling time. Parallel tanks of the kind have been used in war ships. Mr. Biles has carried out a most extended series of model experiments, with the result that while he ascertained that a parallel-sided tank would do very little good in the case of the *City of New York*, he also found a method of constructing the tank which would give perfectly satisfactory results. This he effects by delaying the time of transfer of the water from one side of the ship to the other, which result is brought out by making the tank of a saddle form instead of with parallel sides.

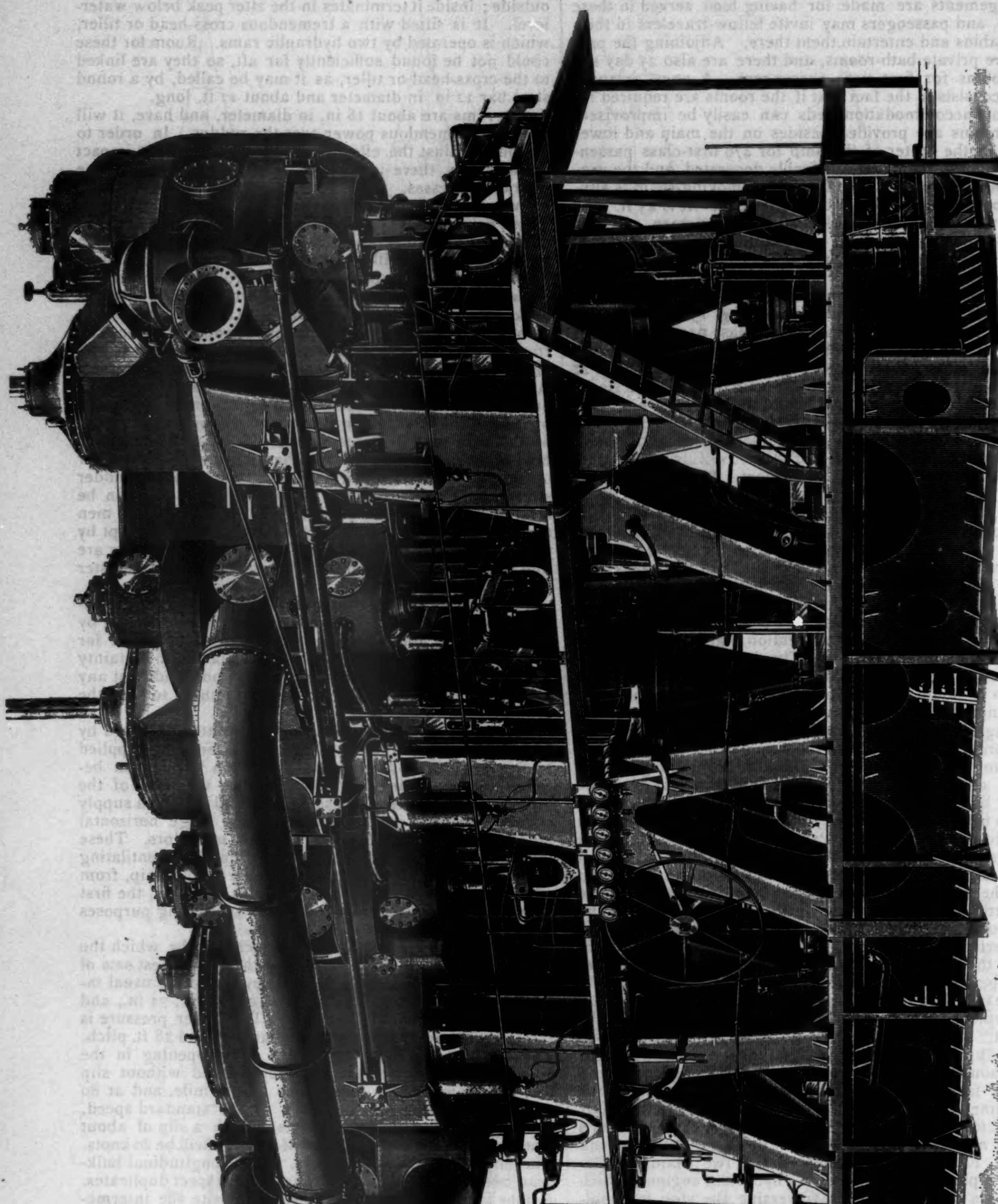
Enormous as tne ship is, she is steered with a tiller like a yacht. Strictly speaking, four tillers are provided, one on the upper or monkey-bridge; one in the so-called wheel-house immediately below; one on the poop, and another far below in the after peak of the ship under the water-line, where also is the hand-steering gear with four wheels, for manual power. The steering gear is Brown's patent, made by Messrs. Brown Brothers, of Rosebank Works, Edinburgh. In each of the two main engine-rooms is placed one of Brown's hydraulic engines, which supplies a system of mains, traversing the ship fore-and-aft, with water at a pressure of about 1,000 lbs. on the square inch. The engines are vertical, compound rotative, and pump the water into a steam accumulator; the steam at 150 lbs. on the square inch driving down a piston, the thick rod of which plays the part of the ram of an ordinary dead weight accumulator. The pressure water is employed for working the hatch derricks, weighing the anchors, etc., and also for steering. The *City of New York* has an enormous rudder, partially balanced, and of peculiar construction. It will be remembered that the ship is on the Admiralty auxiliary list, and in order to render her rudder safe from hostile fire it is wholly submerged. There is no rudder-head to be seen from the outside; inside it terminates in the after peak below water-level. It is fitted with a tremendous cross-head or tiller, which is operated by two hydraulic rams. Room for these could not be found sufficiently far aft, so they are linked to the cross-head or tiller, as it may be called, by a round steel bar 12 in. in diameter and about 12 ft. long.

The rams are about 18 in. in diameter, and have, it will be seen, tremendous power over the rudder. In order to provide against the effect of shocks caused by the impact of the waves, there is a loaded relief valve on each of the hydraulic presses. The water is admitted to either press by valves which are situated near the bow of the ship. These valves are plain slides in a small box, and they are controlled by a tiller about as large as would be used in a 5-ton yacht. The tiller actuates one end of a short lever. The fulcrum end of this lever is controlled by an arm on the vertical spindle of a quadrant which lies under the deck. Two steel wire ropes, each with a breaking strength of seven tons, and stressed to about one-half a ton, run from the rudder-head to the quadrant. The effect is precisely that of the hunting gear in a steam steering gear. As soon as the steersman puts the tiller he holds to port or starboard the appropriate valve just under his feet is opened. The rudder then moves, and through the medium of the wire rope it closes the valve, so that the rudder is held in its new position. Another movement of the tiller opens the valve. The corresponding motion of the rudder shuts it again, and so on. Thus the great ship can be steered by a boy. The practice was so novel to the men that it was difficult at first to get a straight course kept by those who had been accustomed to a wheel; and we are told that the best steersman on board was a quartermaster well up in yacht sailing.

The engines which supply the hydraulic power are extremely ingenious. One very beautiful device is that by which they are automatically rendered non-compound for half a stroke, in order that they may start with certainty after standing. They run quite freely and steadily at any speed, and for any portion of a stroke required to keep the accumulator up.

A complete electrical plant has been fitted on board by Messrs. Brown Brothers & King, the power being supplied by five engines and dynamos placed on a platform between the two main engines and above the level of the tops of the cylinders. These engines and dynamos supply current not only for light, but to four large horizontal fans on the hurricane-deck driven direct by motors. These fans and motors are located in the tops of ventilating shafts extending down into the depths of the ship, from which they draw air. This is, so far as we know, the first time that electricity has been used for ventilating purposes in a ship.

It is now time to speak of the machinery by which the ship is propelled. This consists of the two largest sets of triple-expansion engines afloat. They are of the usual inverted vertical type. The cylinders are 45 in., 74 in., and 113 in. diameter, and 5 ft. stroke. The boiler pressure is 150 lbs. The screws are 22 ft. in diameter and 28 ft. pitch. They revolve outboard, and there is no opening in the dead-wood between them. If they worked without slip they would make 218 revolutions to the mile, and at 80 revolutions, which may be taken as the standard speed, the ship would steam at 22 knots. With a slip of about 9 per cent., therefore, the speed of the ship will be 20 knots. The engines stand side by side, with a longitudinal bulkhead between them. They are in every respect duplicates. A door is provided in the bulkhead opposite the intermediate cranks, and the starting platforms are opposite the doorway. The reversing gear is Brown's patent hydraulic. The engines are quite easily started, stopped, or reversed by one engineer on each platform. The engines are wholly of steel and gun-metal, save the cylinders. The great A-frames are splendid castings, each weighing 6 tons—that is, 12 tons for each cylinder. The valves are all pistons—four being fitted to the low-pressure cylinder, two to the intermediate, and one to the high-pressure cylinder. The eccentric hoops are cast steel, lined with white metal, as are all the bearings throughout. The valves are disposed in the "corners," so to speak, and the valve-stems are united in pairs by cross-heads. They work



TRIPLE-EXPANSION ENGINES, STEAMER "CITY OF NEW YORK."

BUILT BY J. & G. THOMSON, GLASGOW, SCOTLAND.

so smoothly and are so perfectly balanced that the valve gear, which is of the ordinary Stephenson link type, has really very little to do. The surface condensers are horizontal cylinders lying rather high up in the wings. The air-pumps are worked by back levers in the usual way.

There are no feed-pumps on the main engine, the boilers being supplied by five vertical Worthington donkey-pumps in each engine-room, standing against the forward bulkhead. Two of these pumps will feed the boilers, but the others are for reserve, or for the countless pumping jobs wanted in a big ship. The engines actually employed at any time in feeding the boilers are controlled by an automatic arrangement, a float in the hot-well rising or falling with the level of the water in the well, and opening or shutting the throttle valve, an arrangement which is, so far as we are aware, quite new in marine work, and found to answer admirably, the donkey remaining steadily at work instead of tearing away for a few minutes emptying the hot-well, and then having to stand until the well fills again. It would be difficult, if not impossible, to find more admirable examples of the highest type of mechanical engineering than is supplied by the splendid main engines. They have been constructed throughout from the designs of Mr. J. Parker, who also designed the very different, but equally admirable engines of the war-ship *Aurora*. Mr. Parker has brought to bear on his task a lifelong experience. He was for some years second engineer of the great paddle steamer *Persia*, which had side-lever engines, the cylinders 100 in. in diameter, with a stroke of 10 ft. Mr. Parker's familiarity with all the difficulties and trials which beset the sea-going engineer has stood him in good stead; and the engines of the *City of New York* will maintain the fame of Scotch engineers in the New and the Old World. Nothing finer can be imagined than the working of these gigantic engines, with a piston speed of 800 ft. per minute—certainly the greatest velocity ever attained by pistons 9 ft. 5 in. in diameter. During the whole run round Ireland, on the trial trip of the vessel, lasting nearly 46 hours, not a drop of water was needed on a bearing, nor were there the least symptoms of heating.

An important experiment to which we have not yet referred is being carried out in the *City of New York*. Although she is a much larger vessel than the *Umbria* and the *Etruria*, and is intended to be faster than either, she has less boiler power. The *Etruria* has 72 furnaces. The *City of New York* has only 54, disposed in nine double-ended boilers, and containing 1,250 square feet of grate surface. The apparent deficiency is met first by the use of triple-expansion engines, which should be about 20 per cent. more economical than the three-cylinder compound engines of the *Etruria*; and secondly by the use of forced draft. The nine boilers are placed in three stokeholes. The boilers are fired fore-and-aft, and no direct communication between the boiler compartments exists. Access can be had to each only by ladders and hydraulic hoists. There is, we may add, a similar hoist in each engine-room. Instead of the usual forest of cowl ventilators, there are erected at each side of the upper deck six large rectangular structures of heavy plate iron fitted with shield lids, which can be raised or lowered by screw gear. When dropped down, a sufficient space exists for the entry of air. In fine weather they are raised to an inclined position and deflect air down the trunks. These trunks reach down to the fire-rooms, and each is provided at the bottom with a fan about 5 ft. 6 in. in diameter, driven by a separate engine at about 500 revolutions per minute. These fans deliver one at each side of the ship into the six stokeholes, in which they can maintain a plenum of about ½ in. water pressure. So far the result of the experiment is all that can be desired. During her trial trip the pressure of 150 lbs. was maintained in the boilers. The engines made, one 82 and the other 83 revolutions per minute, and a speed of over 20 knots was attained with about 18,500 H.P. No precise data as to power or speed has, however, been officially given. There is every reason to believe that when the engine and fire-room hands have thoroughly settled down to their work, 20,000 H.P., or a little more, will be obtained.

The *City of New York* has now made her first trip across the Atlantic, but no statement of the working of the engines has been made public.

UNITED STATES NAVAL PROGRESS.

NEXT to the *Charleston*, which was launched at San Francisco in July, the most advanced of the new cruisers is the *Baltimore*, which was to be launched from Cramp's yard on the Delaware about the close of August. The *Baltimore* is an unarmored cruiser like the *Charleston*, but is somewhat larger than that vessel, having a displacement of 4,400 tons. She is 315 ft. long, 48½ ft. beam, and will have a maximum draft of 21 ft. The contract price for the hull and engines is $1,325,000, and she was to have been completed in June, but the time has been extended, chiefly owing to delays in inspection and delivery of the steel of which her hull is constructed. The *Baltimore* has a double bottom, and is divided into many compartments by water-tight bulkheads. As stated above, she is an unarmored vessel, but has a protective or armored deck varying from 2½ to 4 in. in thickness, while the arrangement of the bulkheads and coal-bunkers is such as to protect the machinery and vital parts of the vessel as far as possible. She will have no sail power for ordinary use, but will be provided with storm-sails carried on the two military masts, both of which are fitted with fighting tops.

The main battery of the *Baltimore* will consist of four 8-in. and six 6-in. breech-loading rifled guns, while she will have as a secondary battery 11 Hotchkiss and Gatling guns, and will also carry a torpedo equipment.

The design of the *Baltimore* was originally from Mr. White, who was, at the time the plans were furnished, in the employment of the famous English firm of Armstrong & Company, and who is now Constructor in the British Navy. The plans were somewhat modified in our Navy Department, but are substantially those made by Mr. White.

Like the other cruisers, the *Baltimore* has two screws with triple-expansion engines; these engines will work up to 10,500 H.P. with forced draft, and the contract speed will be 19 knots an hour, which is greater than that of any of the vessels which have preceded her. She will carry coal enough to give her a very extended cruising range at a moderate speed, and is expected to be an exceedingly useful vessel.

The preparations for building the armored cruiser *Maine* at the New York Navy Yard are well advanced, and work will be begun as soon as a good supply of material is delivered. The *Maine* is the heaviest of the vessels yet authorized for the new Navy, and differs from the earlier cruisers, like the *Atlanta*, the *Boston*, the *Charleston*, and the *Baltimore*, in carrying heavy armor. She is of what is known as the belted cruiser type, with armored turrets, the heavy guns being carried in turrets raised above the main deck, while an armored belt protects the vital parts of the ship. The design is very similar to that of the cruiser *Riachuelo*, built recently for the Brazilian Government, the performance of which has been very good.

The general dimensions of this ship are: Length between perpendiculars, 310 ft.; extreme breadth, 57 ft.; mean draft, 21½ ft.; displacement, 6,650 tons. The armor belt will be 11 in. thick, extending 180 ft. amidships, from 3 ft. above to 4 ft. below the water line. The steel armor-plates are to be carried on wood backing 8 in. thick, and at the forward end of the belt there is a bulkhead 6 in. thick running entirely across the vessel.

The revolving turrets will be protected by steel armor-plates 10½ in. thick. On the raised casemate there is a conning-tower of elliptical form 10½ by 9 ft., protected by armor 10 in. thick. The ship will have a double bottom, with the usual arrangement of coal-bunkers, etc., to protect the engines as much as possible.

The *Maine* will have three masts and will be bark-rigged; the fore and main masts are to be fitted with military tops, each carrying two small machine guns. In addition to the usual allowance of boats, including two steam launches, she will carry on deck two torpedo-boats, each 60 ft. long. The principal battery will consist of four 10-

in. steel breech-loading guns, two mounted in each of the turrets, the latter to be arranged in *echelon*, so that all four guns can be fired ahead or astern at the same time; the 6-in. guns are mounted in the raised central breastwork or casemate, having especial protection for their gunners in the form of steel shields 2 in. thick. Two of these 6 in. guns are placed forward and two aft, while the remaining two are mounted one on each side of the central structure. The secondary battery consists of four 57-mm. rapid firing guns, four 47-mm. guns of the same kind, four 47-mm. and nine 37-mm. revolving cannon and four Gatling guns. There will be also seven torpedo tubes, which can be used on occasion. The 10-in. guns will use a projectile of 500 lbs. weight with 250 lbs. powder, and are expected to have a maximum range of nine miles.

In the design of this vessel great care has been taken to provide convenient quarters for the officers and crew. She will be fitted with elaborate systems of pumping and ventilation by machinery, and is provided with several dynamos which will serve to light the vessel throughout with incandescent lights, and also to supply three powerful search-lights. The electric arrangements will be so made that in case of damage to one dynamo, connections can be at once made with another.

The *Maine* will have two screws driven by two triple-expansion engines, each placed in a separate water-tight compartment. Each of these engines has cylinders 35½, 57 and 88 in. in diameter, with a stroke of 36 in. Steam will be furnished by eight cylindrical return tubular boilers 14 ft. 8 in. diameter and 10 ft. long, each having three furnaces. Forced draft will be secured by leading air to the under side of the grate-bars and there will be four blowers, having a total capacity of 26,000 cubic feet of air per minute. With forced draft the engines are expected to develop 8,750 H.P. The total capacity of the coal-bunkers will be somewhat over 800 tons, and with a full supply the ships will be able to steam 1,900 knots at full speed, 3,200 knots at 15 knots an hour, and 8,500 at 10 knots an hour, thus giving her a large cruising range at low speed.

The cruiser *Atlanta* is to receive some repairs and slight alterations, as recommended by the officers who have been in charge of her, and will then be sent on an extended cruise.

The Naval Appropriation Bill has not yet been acted upon in Congress, so that it is uncertain whether the large cruisers proposed will be authorized this year or not. It seems probable, however, that the bill will pass in something like the form which it has received.

Blast Furnaces of the United States.

THE *American Manufacturer*, in its statement of the condition of the blast furnaces on August 1, sums up the totals as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,248	103	11,666
Anthracite	92	27,846	108	27,498
Bituminous	119	77,408	103	49,878
Total	280	118,502	314	89,042

"The table shows that the number of furnaces in blast was 280, or 3 less than the number in blast on July 1. The number of bituminous furnaces in blast shows no change; there is a decline of 4 in the number of anthracite furnaces blowing, and a gain of 1 in charcoal. The weekly capacity of the furnaces in blast was 118,502 tons, compared with 115,672 tons on July 1—an increase of 2,830 tons. The increase was confined to the charcoal and the bituminous furnaces, as follows: Charcoal—increase, 495 tons; bituminous—increase, 2,665 tons; anthracite—decrease, 330 tons.

"The appended table shows the number of furnaces in blast August 1, 1888, and August 1, 1887, with their weekly capacity:

	Aug. 1, 1888.		Aug. 1, 1887.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,248	80	14,396
Anthracite	92	27,846	127	35,278
Bituminous	119	77,408	120	70,855
Total	280	118,502	327	120,529

"Since January 1, 1888—seven months—there has been a decrease of 61 furnaces in blast, the decrease in weekly capacity being 22,218 tons."

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(Continued from page 376.)

CHAPTER XIII.—*(Continued.)*

QUESTION 376. *What are the principal causes which affect the form of the diagram?*

Answer. 1. The friction of the steam in the pipes and ports.

2. The variable size of the openings of the steam-ports as caused by the gradual motion of the side-valve.

3. The action of the internal surfaces of the cylinder in causing condensation and partial re-evaporation of some of the entering steam.

4. The steam contained in the clearance spaces which affects the curve of expansion.

5. The gradual opening of the exhaust-port, which makes it necessary to release the steam too early in the stroke.

6. The friction of the exhaust passages, which increases the back pressure.

7. The clearance spaces, which, combined with the unavoidable nature of the action of a slide-valve driven by a link-motion and the momentum of the moving parts, make compression necessary.*

QUESTION 377. *How can we determine whether the steam is distributed in the cylinders to the best advantage, and how can we discover the fault, if there is one, in the link-motion?*

Answer. The indicator will show the action of the steam in the cylinder, and motion-curves drawn with the instrument described in answer to Question 192 will show the exact movement of the valve. By comparing the indicator diagram with the motion-curves, the one will show the defects in the other.†

QUESTION 378. *To what extent can the movement of the valve be modified by alterations in the proportions of the link-motion?*

Answer. The motion of the valve is susceptible of an almost infinite number of changes, by different variations and combinations of proportions of the working parts of the link motion. These changes are, however, limited by the general laws which govern the motion of eccentrics, and therefore cannot influence the motion of the valve beyond certain limits. Hardly any variation can be made either in the proportions or arrangement of the working parts which will not have some influence upon the movement of the valve. Aside from the proportions of the valve itself, which have already been discussed, the throw of the eccentrics, the length of the rods and of the link, the point of connection of the rods with the link, the point of suspension, the position of the lifting-shaft, the length of the arms, the length and position of the rocker-arms, will each of them effect the distribution of steam. The number of combinations of all these different proportions is, of course, almost infinite, and therefore any full discussion of them will be impossible here.

QUESTION 379. *What are the most important points which require attention in designing a link-motion?*

Answer. It should be proportioned so that—

1. The lead and the period of admission should be the same for each end of the cylinder, for each point of cut-off, and, if possible, in back as well as forward gear.

2. The width of opening for both admission and exhaust should be as large as possible when steam is cut off short.

3. The exhaust or pre-release should occur early enough and be maintained long enough to reduce back-pressure as low as possible.

QUESTION 380. *In designing valve-gear how is it usually tested?*

Answer. Usually a full-sized model is made, the various parts of which are made adjustable, so that the proportions and position of the different parts may be varied, so that the best possible movement of the valve may be obtained. If mechanism for drawing diagrams of the motion of the valve similar to that illustrated in fig. 222 is added to the model, the action of the valve-gear can be completely delineated.

QUESTION 381. *How can the lead and periods of admission of a slide-valve be equalized at each end of the stroke of the piston?*

Answer. It is impossible to make the periods of admission absolutely alike for every point of cut-off in both fore and back gear. It is, therefore, customary to disregard the back gear, as

* Questions 375 and 376 were suggested by George C. V. Holmes's excellent book on the steam-engine, and the answers thereto were in substance taken therefrom.

† See description of Richards's Improved Steam-Engine Indicator, with directions for its use, by Charles T. Porter, London.

engines are worked but little with the link in that position. Even for forward gear the periods of admission cannot be made exactly alike for each end of the cylinder and for each point of cut-off, and therefore it is usual to make the periods of admission alike for half-gear forward, in which position the link is worked most.

The periods of admission for the front and back ends of the cylinder can be changed most in relation to each other by altering the position of the point of suspension on the link. This can be done either by moving this point up or down, or horizontally. Usually links are suspended from a point halfway between the points of connection of the eccentric-rods and from ¼ to ¾ in. back of the center line of the slot in the link. A somewhat better distribution can be secured by suspending them about 3 in. above the center, but the suspending-links must then be made so short that they are subjected to very great strains by the motion of the link, and this evil is usually considered much greater than the advantage which is gained thereby in the more equal distribution. The point at which the upper end of the suspension-link is hung also influences the relative amount of admission front and back. This point, of course, varies as the end of the lifting-arm is raised or lowered. The best position for the lifting-shaft and the length of its arm can be determined, perhaps, most satisfactorily by placing the link in full gear forward, then moving the point of suspension of the upper end of the link-hanger horizontally, so that the front and back admission will be alike, and then marking this position. The same process should then be repeated for half-gear and for the shortest point of cut-off. If the position of the lifting-shaft and the length of its arm are then so arranged that the end of the latter will move through the three points which have been thus determined, the admission will be very nearly equal for each end of the cylinder. Usually, however, it is impossible to arrange the shaft and arm so that they will conform exactly to these conditions, and therefore an approximation is made which will come as near as possible to what is required. It may be stated, however, that the lifting-shaft should be kept as low as possible, so as not to interfere with the eccentric-rods. In some cases the shaft has been suspended from the boiler, so that the outside eccentric-rod would work past or over the end of the lifting-shaft, thus allowing the latter to be located lower than would otherwise be possible.

Fig. 246.

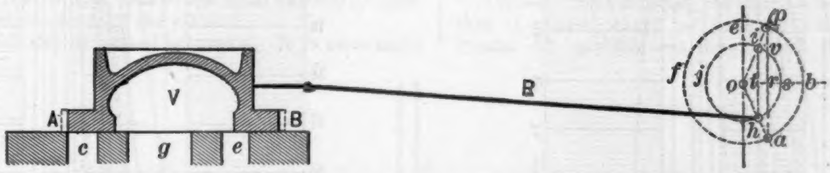


Fig. 247.

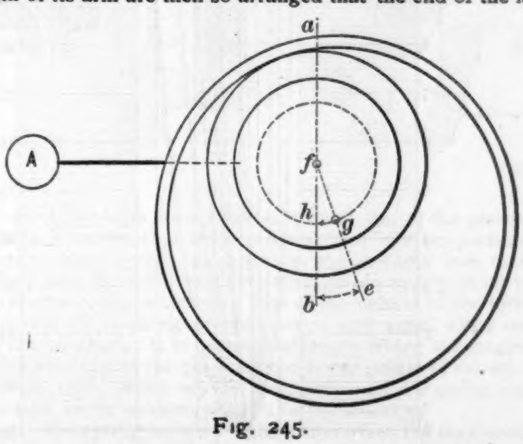


Fig. 245.

QUESTION 382. *Which parts of the link-motion have the greatest influence on the distribution of steam?*

Answer. The lap of the valve and the throw of the eccentrics. The effect of any change of these upon the distribution is very similar to that produced if a single eccentric is used, which was explained in the answers to Questions 120 and 121.

QUESTION 383. *What is the effect upon the admission of increasing the throw of the eccentrics with the same lap?*

Answer. As already explained, the effect is to increase the period of admission, or, in other words, to cut off later in the stroke, and also to increase the width of the opening of the steam-port or the distance which the valve throws over the port. This has an important influence upon the admission, when the link-motion is used.

QUESTION 384. *What is meant by the angular advance of the eccentrics?*

Answer. It is the angle which a line, *e f*, fig. 245, drawn through the center *f* of the axle and the center *g* of the eccentric makes with a vertical line, *a b*, also drawn through the center of the axle when the crank is on one of the dead-points or centers. Thus in fig. 245 the crank-pin *A* is represented on the front center. In order to give the valve the necessary lead the eccentric must be moved back of the vertical line *a b*. The angle *b f e* which the line *e f* (drawn through the center *g* of the eccentric and *f* of the axle) makes with the vertical line is called the *angular advance*.

QUESTION 385. *What is meant by linear advance?*

Answer. By linear advance is meant the distance which the valve has moved from its middle position at the beginning of the stroke of the piston. This, when the two rocker-arms are the same length, is the same as the distance *g h* of the center of the eccentric *g* from the vertical line, *a b*, fig. 245.

QUESTION 386. *Why does the cut-off occur earlier with an eccentric having a short throw than with one which gives more travel to the valve?*

Answer. Because it is necessary to give the eccentric with the short throw more angular advance—that is, it must be set "farther ahead" in order to give the valve the required lead. This is illustrated in fig. 246, in which a section of a valve, *V*, and ports, *c*, *g*, and *e*, are represented. In order to simplify the diagram as much as possible the rocker is left out and the valve is supposed to be moved by the rod *R* directly from the center *a* of the eccentric.* The effect of the angularity of the connecting-rod and eccentric-rod is also neglected. The circle *a b e f* represents the path of the center of an eccentric having 5-in. throw, and *h s i j* the path of one having 3½-in.-throw. In order to give the valve the required lead, which is supposed to be just line-and-line at the beginning of the stroke, the linear advance of the valve must be equal to the lap, or ⅞ in. If, therefore, we draw a line, *p a*, parallel to the vertical center line, *e k*, and ⅞ in. from it, the intersection of *p a* at *a* and *h* with the paths of the eccentric will be the centers of the eccentrics. If through these centers and the center of the circle, lines *o a* and *o h* be drawn, the angles *k o q* and *l o m*, which they make with the vertical *e k*, will represent the angular advance. It will be seen from these lines, and by comparing these two angles, that in order to give the valve the required lead, it is necessary to give the eccentric with the small travel more angular advance than is necessary for the one with the larger throw. It is obvious, too, that when the center of the larger eccentric has reached the point *b* the valve will have received its greatest travel, and that when it reaches *p* the steam-port *e* will again be closed or the steam cut off. If the small eccentric is employed, the valve will have its maximum travel when the center *h* reaches *s*, and the port will be closed when it reaches *i*. By drawing lines *o p* and *o n* through *i* and *p*, it will be seen that from the beginning of the stroke until the steam is cut off, if the large eccentric is employed, it, and consequently the shaft and crank, must move over an angle measured by the arc *q t p*. If the small eccentric is used, it and the crank must move through an angle measured by the arc *u t n*. In other words, the crank must turn a considerably greater distance before steam is cut off with an eccentric having a large than with one having a small throw.

* It will be seen that this causes the position of the center of the eccentric to be reversed.

It is also quite obvious from fig. 246 why the port is opened a shorter distance with a small than with a large eccentric. The distances *o s* and *o b* are equal to half the throws of the eccentrics, or 1¾ and 2½ in. The linear advance *o r* is in both cases ⅞ in., and therefore after the port begins to open the valve will be moved by the small eccentric, a distance which is equal to 1¾ − ⅞ = ⅞ in., and by the large one 2½ − ⅞ = 1⅝ in.

QUESTION 387. *What is the effect on the admission of giving an eccentric with a small throw the same angular advance as one with a large throw, and then reducing the lap of the valve so that the lead will be the same in both cases?*

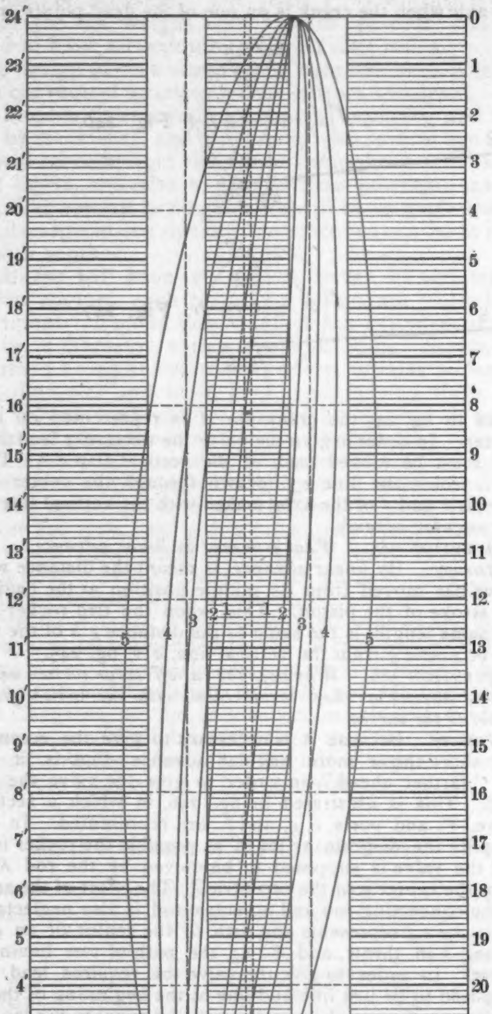


Fig. 248.

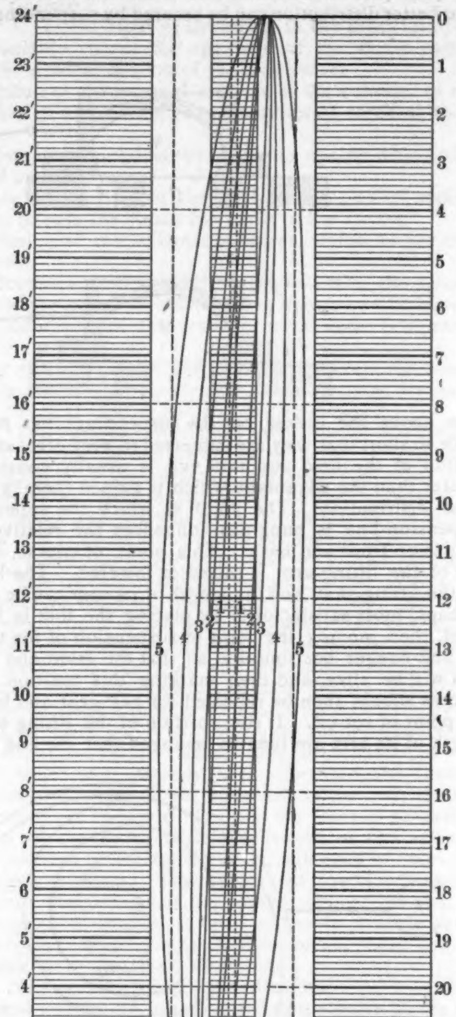


Fig. 249.

Answer. The admission and the cut-off will then occur at the same points of the stroke, but the ports will not be opened so wide. This is illustrated in fig. 247, in which the paths of two eccentrics having the same throw as those in fig. 246 are represented. The centre *a* of the larger eccentric is represented in the same position in fig. 247 as in fig. 246. If a line is drawn from the center of the larger eccentric to *o*, the center of the axle, and if the center *h* of the smaller eccentric is located on the intersection of this line with the circle *h s i j*, which represents its path, then the smaller eccentric will have the same angular advance, but the linear advance measured by the distance *o t* will be only ⅝ in. If the valve has the same lap as in fig. 246, its steam edges at the beginning of the stroke—if the small eccentric is employed—will occupy the position represented by the dotted lines *A* and *B*. If these edges are cut off, as shown by the full lines and shading, then the valve will have the same lead as in fig. 246. It is obvious, too, that if the smaller eccentric has the same angular advance it will reach the point *v*, at which, with the reduced lap, the steam will be cut off, at the same time that the center *a* of the large eccentric will reach *p*, at which point it cuts off the steam with the valve having the large lap. There is, however, this difference in the distribution, that in the one case the valve opens the port a distance equal to *t s*, and in the other a distance equal to *r b*. As *o t* is equal to the linear advance of the small eccentric, or ⅝ in., and *o s* to half the throw of the eccentric, or 1¾, *t s* is equal to 1¾ − ⅝ = 1⅛ in. The distance *r b*, as shown above, is equal to 2½ − ⅞ = 1⅝ in., so that the effect produced upon the admission of using an eccentric with a small throw and corresponding amount of lap is, that the ports are not opened so wide as with an eccentric having a larger throw.

QUESTION 388. *How do eccentrics with a short throw and valves with a corresponding amount of lap affect the admission with a link-motion as compared with eccentrics having a larger amount of throw and greater lap of valve?*

Answer. The chief difference is that the ports are not opened so wide for the same period of admission. Thus a series of motion-curves is shown in fig. 248, drawn with a model of a link-motion like that illustrated in fig. 222. The eccentrics had 5-in. throw, and the valve ¾-in. lap outside and $\frac{1}{16}$-in. inside. Fig. 249 represents a series of curves, drawn with the same arrangement of valve-gear, excepting that the eccentrics had 3½-in. throw and the valve ½-in. lap. In both cases the curves represent the motion of the valve when cutting off at the same point

of the stroke. The following table will show the relative amount of opening of the port.

Point of Cut-Off.	Width of Opening of Steam-Port.	
	Eccentric 5-in. throw.	Eccentric 3½-in. throw.
6 in.	$\frac{7}{32}$ in.	$\frac{5}{32}$ in.
10 "	$\frac{11}{32}$ "	$\frac{7}{32}$ "
15 "	$\frac{5}{8}$ "	$\frac{3}{8}$ "
18 "	$\frac{31}{32}$ "	$\frac{11}{16}$ "
21 "	$1\frac{1}{4}$* "	$1\frac{1}{32}$ "

* The valve throws over the steam-port ⅝ in. at this point.

It will be seen from this that the eccentric with 5-in. throw gives a greater width of opening for every point of cut-off than the one with 3½-in. throw. For the higher admissions this is not important, but when steam is cut off short it will be observed that the width of the opening is very small. At high speeds the small opening is a great disadvantage.

QUESTION 389. *Has it been determined what amount of opening is required for given speeds of the piston?*

Answer. Not with any degree of accuracy. It is customary to make the area of the ports about one tenth that of the piston. It is certain, however, that with steam-ports of this proportion, excepting at high speeds, an opening considerably less than their whole area is sufficient to maintain steam nearly equal to boiler pressure in the cylinders. One of the defects of the link-motion is that the opening of the port is very small when the steam is cut off short. It is best, therefore, to secure the largest practicable opening of the ports for the lower points of cut-off.

QUESTION 390. *What are the proportions of the valves and eccentrics used in the ordinary practice in this country?*

Answer. Excepting for very light locomotives the maximum travel varies from 4½ to 5½ in., the outside lap from ⅝ to 1¼ in., the inside lap from $\frac{1}{16}$ to $\frac{3}{16}$ in., and the lead in full gear from $\frac{1}{16}$ to ⅛ in.

QUESTION 391. *What should be the width of the bridge between the steam and exhaust ports?*

Answer. It is usually made about the same thickness as the sides of the cylinder, in order to secure a good casting; but sometimes it is necessary to make it wider, in order to prevent steam from escaping from the steam-chest into the exhaust, which is apt to be the case if a valve has little lap and a long travel.

QUESTION 392. *What determines the width of the exhaust-port?*

Answer. The throw of the valve. This will be clear if we refer to fig. 52. The port *g* should be wide enough so that when the valve is at the end of its travel the opening *h i* of the exhaust-port is not contracted too much. If this opening is not wide enough it will prevent the free escape of the exhaust-steam and increase the back pressure.

It is, therefore, best to make the exhaust-port so wide that with the greatest travel of the valve the width of its opening will be nearly equal to the width of the steam-ports.

QUESTION 393. *What effect does the steam have on a slide-valve?*

Answer. It exerts a pressure nearly or quite equal to the area of the top of the valve multiplied by the pressure of steam on a unit of that area. Thus a valve when outside dimensions are 9 × 18 in. would have an area of 162 square in. If a boiler pressure of 140 lbs. per square in. is exerted on the whole of this area it would be equal to 162 × 140 = 22,680 lbs. The actual pressure exerted by the steam on the valve is, however, very irregular, as during some portions of the stroke the steam in the ports under the valve exerts an upward pressure, which opposes that on top. The pressure on top is also influenced by the fit of the valve to its seat. If it is not steam-tight more or less steam will get between the valve and its seat, and thus counteract the pressure on top, whereas if the valve is perfectly steam-tight, no such action will occur. In any event, however, the pressure on top of slide-valves will be very great, and much power is required to move them when the engine is working, unless the pressure is relieved in some way.

QUESTION 394. *How is the pressure on slide-valves relieved?*

Answer. By excluding the steam from the top of the valve so that it cannot exert its pressure on it. This is done by means of packing on the top of the valve, which bears against a plate above. This packing consists either of rings or straight strips of metal, *p p*, fig. 250, but the latter are arranged in rectangular form and held in grooves on top of the valve. These bear against a plate, *P*, attached to the steam-chest cover, which is planed and scraped so that the surfaces of contact of the packing against the plate are steam-tight. The packing is also made steam-tight where it is in contact with the valve, and is held up against the plate by springs underneath. Steam is thus excluded from the top of the valve at *a a*. A hole, *o*, in the valve allows any steam which might leak past the packing to escape into the exhaust cavity *V*. A relief valve *R* is attached to the steam-chest to admit air and prevent it from being sucked in through the exhaust-pipes, when steam is shut off, and the action of the piston creates a partial vacuum in the steam-chest. If air was sucked in through the exhaust pipes cinders and other gritty substances would be drawn in with it, and would be liable to cut the valve-face and the inside of the cylinder. When a vacuum is produced in the steam-chest the valve is raised up by the pressure of the air below, and it flows in through openings underneath, as indicated by the arrows. The valve represented by the engraving is what is known as Richardson's balanced valve.

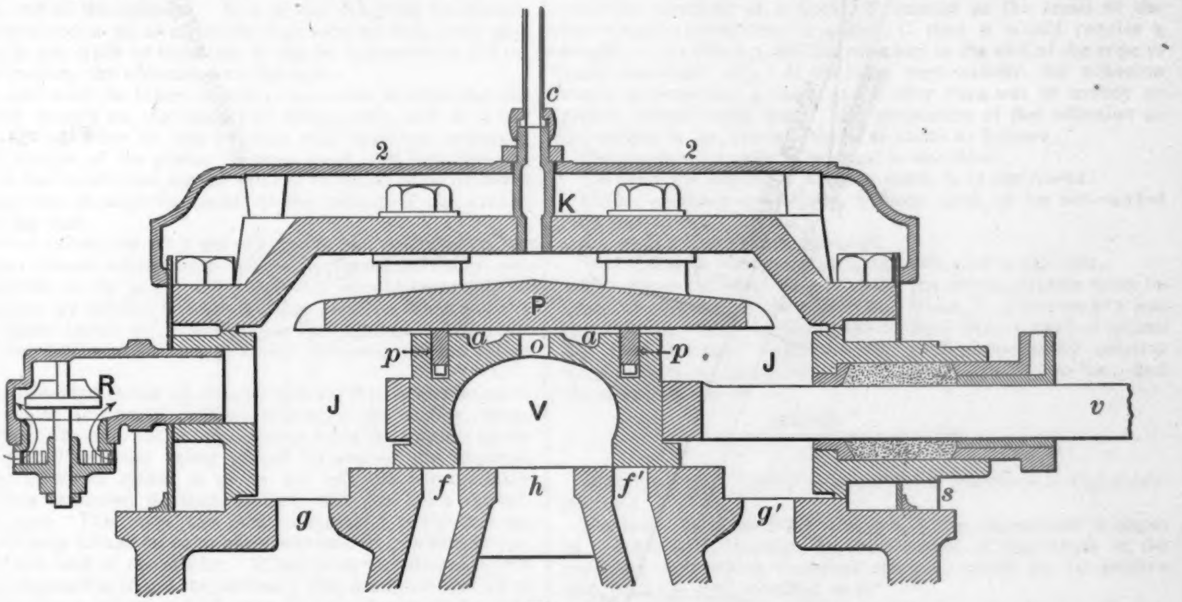


Fig. 250.

QUESTION 395. *How are the notches in the sector arranged?*

Answer. They are often arranged so that the steam will be cut off at some full number of inches of the stroke when the reverse-lever is in each one of the notches. They are then located so that the steam will be cut off at 6, 9, 12, 15, 18, and 21 inches, or at 6, 8, 10, 12, 15, 18, and 21 inches of the stroke. A notch is also placed so as to hold the link in mid-gear. In other

cases as many notches as there is room for are put into the sectors. The latter seems to be much the best plan, as it gives more gradations in which the valve-gear can be worked, and it is a matter of no consequence whatever in the working of an engine whether the steam is cut off at some full or some fractional number of inches of the stroke.

QUESTION 396. *Where is the reverse lever located and how is it constructed?*

Answer. It is located in the cab and above the *foot-board** 93, as shown in Plates III and IV. It consists of a lever, 20, 21, with the fulcrum at the lower end. The *reverse-rod* 19, 21, which connects the lever with the vertical arm 18 of the lifting-shaft, is attached above the fulcrum of the reverse lever. Fig. 251 represents a side view of the lever on an enlarged scale and with some of the details attached, which are omitted on Plates III and IV. *S S'* are two curved bars, which in this

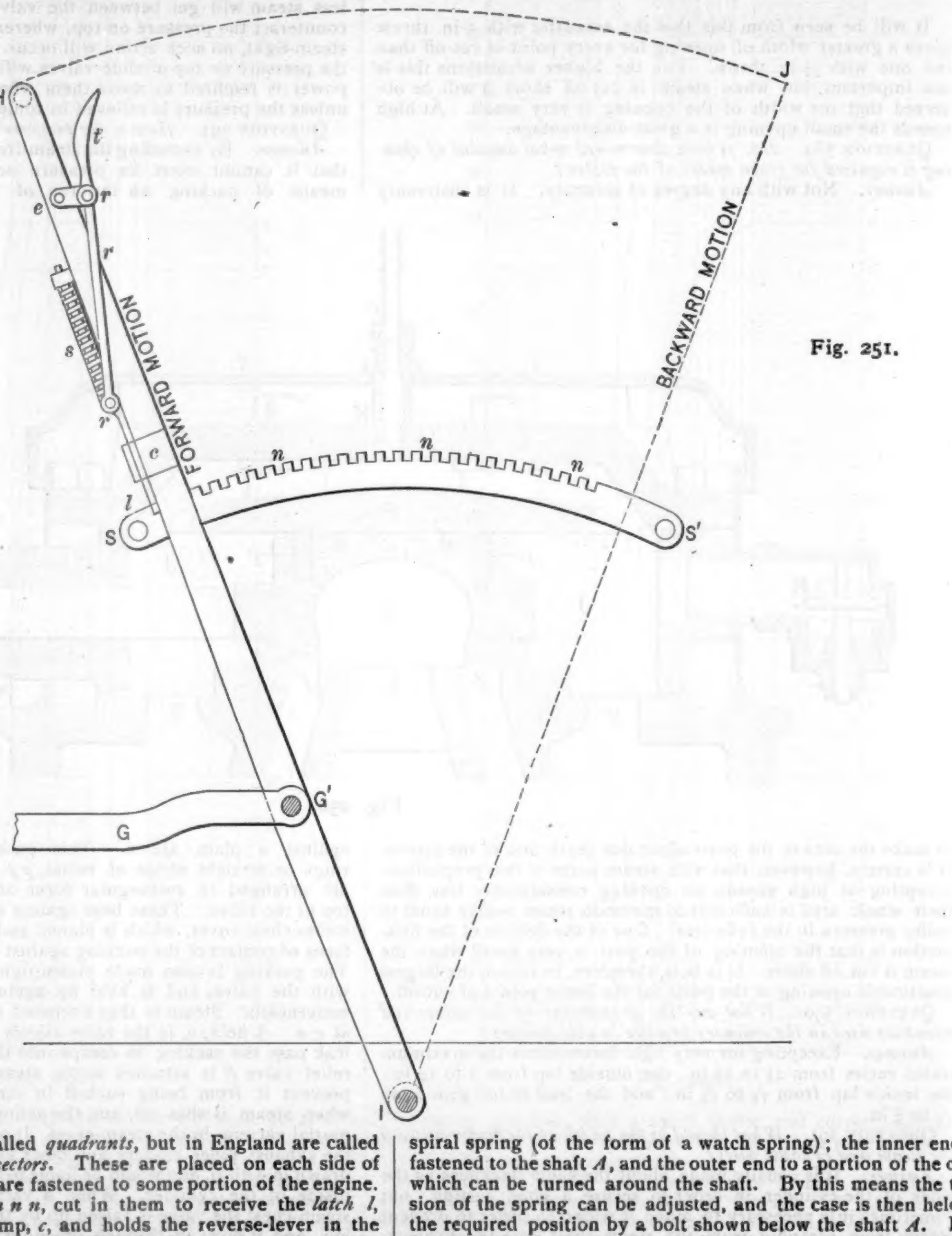


Fig. 251.

country are usually called *quadrants*, but in England are called (and more properly) *sectors*. These are placed on each side of the reverse-lever and are fastened to some portion of the engine. They have notches, *n n n*, cut in them to receive the *latch l*, which slides in a clamp, *c*, and holds the reverse-lever in the notches in which it is placed. This latch is operated by a *trigger, t*, which is grasped by the locomotive runner when he takes hold of the handle *H* of the reverse-lever. The trigger works on a pin, *e*, as a fulcrum, and is attached to the latch by a rod, *r r*. When the trigger is pressed up against the handle, the latch is raised out of the notches by the rod *r r*, and is pressed into them again by the spring *s* when the trigger is released.

* The *foot-board* 93, plates III and IV (see JOURNAL for May), is a platform for the locomotive runner and fireman to stand on, and is located at the back end of the engine.

The reverse rod *G G'* is connected to the lever at *G'*, and is part of the rod indicated by the same letter in fig. 198.

QUESTION 397. *How long should the reverse-lever be?*

Answer. The lever should be sufficiently long, so that in throwing the link from full gear forward to full gear backward the handle *H* will move *not less* than four times the distance that the link is moved. It is much better to give the end of the handle five or even six times the motion of the link, as there will then be a much easier action in reversing the engine. This will also make it possible to use longer sectors and give room for more notches.

QUESTION 398. *What provision is made in the reversing gear for overcoming or neutralizing the weight of the link and other parts of the valve-gear?*

Answer. Their weight is counterbalanced by the pressure of a spring of some kind. In fig. 198 the case *H* contains a spiral spring (of the form of a watch spring); the inner end is fastened to the shaft *A*, and the outer end to a portion of the case which can be turned around the shaft. By this means the tension of the spring can be adjusted, and the case is then held in the required position by a bolt shown below the shaft *A*. Different kinds of springs are used for this purpose, and sometimes are attached to the reverse-lever instead of to the lifting-shaft.

QUESTION 399. *What is meant by "setting" a slide-valve?*

Answer. It is to fasten the eccentrics in the right position on the axle and to adjust the length of the eccentric-rods and valve-stem so that the valves will give the required distribution of steam.

QUESTION 400. *How are the valves of a locomotive set?*

Answer. After the wheels, axles, main connecting-rods and valve-gear are connected together, put the rocker-arm in its

middle position, and lengthen or shorten the valve-stem, so that the valve will then be in the center of the valve-face. Then place the crank on the forward center and the full part of the forward motion eccentric above and that of the backward motion eccentric below the axle, and fasten them to the axle temporarily by tightening up the set-screws. Then throw the link down until the block comes nearly opposite to the end of the eccentric-rod, and turn the wheels,* and at the same time observe whether the travel of the valve is equal to the throw of the eccentric and also whether it travels equally on each side of the center of the valve-face. If its travel is greater than the throw of the eccentric, raise the link up; if less, lower it down until the two are just equal, and then mark the position for the notches on the sectors or quadrants to receive the latch of the reverse-lever. If the valve does not travel equally on each side of the center of the valve-face, either lengthen or shorten the eccentric-rod, as may be necessary. Repeat this operation for the backward motion, by raising the link up until the block is opposite the end of the lower eccentric-rod. After having done this, go over the whole process again to see whether it is all correct. Now with the crank on the forward center and the link in full gear forward, loosen the set-screws in the forward eccentric, and move it around the axle so that the valve will have the required lead and then fasten it again. Now raise the link up into full back gear, and set the backward eccentric in the same way. Then turn the wheels so as to bring the crank on the back center, and observe whether the lead is correct for the back end of the cylinder. If it is not, lengthen or shorten the eccentric-rod so as to make the lead alike at both ends, and if then it is too much or too little, it can be increased or diminished by moving the eccentrics on the axle.

Great care must be taken in setting valves to be sure that the cranks are exactly on the centers or dead-points, and it is impossible to set them in that position with sufficient accuracy from the motion of the piston or cross-head, and therefore the centers of the crank-pins should always be set so as to conform to a line drawn through the center of the cross-head pin, crank-pin, and the axle.

When the valves are set it should also be noticed whether the axle-boxes (whose construction will be explained hereafter) are in the middle of the jaws, and if not they should be moved to that position by driving wooden wedges between them and the frames, either above or below, as may be required. The position of the boxes has a very material influence on the valve-gear.

If it is intended to lay off the notches on the sectors so as to cut off steam at certain definite points of the stroke, these points should be laid off in the guides from the motion of the cross-head. The latter being placed in any of the required positions at which steam is to be cut off, the reverse-lever should then be moved so that the link will just close the admission port. The lever can then be clamped to the sectors, and the wheels turned so as to show whether its position is correct for each end of the stroke. It has been mentioned before that it is impossible to get the ordinary link-motion to cut off at exactly the same points at both ends of the cylinder, but a very close approximation can be made by proportioning the different parts properly. As has already been stated, it is a much better plan to put as many notches in the sectors as possible than to locate them for certain definite points of the stroke.

In setting the valves of locomotives, care must be taken to turn the wheels *forward* for the *forward motion* and *backward* for the *backward motion*.

After the valves are set the position of the eccentrics on the shaft should be marked, so that in case they become loose on the road they can easily be set again. It is usual, too, to mark the position of the valves with center-punch marks on the valve-stem and on the stuffing-box of the steam-chest, so that with a gauge made for the purpose the position of the valve can be determined without taking off the steam-chest cover.

In some cases the eccentrics are keyed on, which is done after their position is determined by setting the valves. The ends of the set-screws which are used to fasten the eccentrics should be cup-shaped and case-hardened, so as to hold as securely as possible to the axle when they are screwed down.

After the valve is set on one side of the engine that on the other side should be tested for each point of cut-off so as to be certain that the two valves work alike. It sometimes happens that the link-hanger or suspension link on one side must be either lengthened or shortened, so that the two links will occupy the same relation to their rocker-pins.

If the valves are set when the engine is cold they should be tested after it has been fired up, as the expansion of the parts may affect the action of the valves.

* This can be done by moving the engine on the track or by raising it off its wheels, so that the latter can be turned without moving the former. In some shops a pair of rollers is put in the track, so that by placing the driving-wheels on them they can be turned without any difficulty.

CHAPTER XIV.

ADHESION AND TRACTION.

QUESTION 401. *What is meant by the "adhesion" of a locomotive?*

Answer. It is the resistance which prevents or opposes the slipping of the driving-wheels on the rails, and is due to the friction of the former on the latter.

QUESTION 402. *On what does the amount of this friction depend?*

Answer. Like all friction, it depends upon the weight or pressure of the surfaces in contact, and consequently upon the load which rests on each wheel. It also depends upon the condition of the rails, and probably to some extent upon the material of which they and the tires on the wheels are made.

QUESTION 403. *How much force is required to make the driving-wheels of a locomotive slip on an ordinary railroad track?*

Answer. The force required to make them slip will, as already stated, vary very much with the condition of the rails. If they are quite dry and clean it will require a force equal to about one-fourth the weight on the wheels. That is, supposing we have a wheel, *A B*, fig. 252, attached to a frame which is fastened so that it cannot move, and that the wheel rests on a rail and is loaded with say 12,000 lbs., if now a rope or chain could be attached at a point, *B*, exactly at the tread of the wheel, and carried over a pulley, *C*, then it would require a weight, *D*, of about 3,000 lbs. attached to the end of the rope to make the wheel slip. If the rails were sanded, the adhesion would be somewhat greater, and if they were wet or muddy or greasy, considerably less. The proportion of the adhesion to the weight in the driving-wheels is about as follows:

On dry-sanded rails it is equal to *one-third*.

On perfectly dry rails, without sand, it is *one-fourth*.

Under ordinary conditions, without sand, or on wet-sanded rails, *one-fifth*.

On wet or frosty rails, *one-sixth*.

With snow or ice on the rails, the adhesion is still less.

Of course the total weight on all the driving-wheels must be taken in calculating the adhesion. Thus, if a locomotive has four driving-wheels, and each one of them bears a load of 12,000 lbs., then the total weight on the driving-wheels, or *adhesive weight*, as it is called, will be $12{,}000 \times 4 = 48{,}000$ lbs., and the adhesion will be

$$\frac{48{,}000}{5} = 9{,}600 \text{ lbs.}$$

QUESTION 404. *What is meant by the tractive power of a locomotive?*

Answer. It is the force with which the locomotive is urged in a horizontal direction by the pressure of the steam in the cylinders, and which therefore tends to move the locomotive and draw the load attached to it.

The tractive power is due to the pressure of steam on the pistons, and therefore its amount is dependent upon the average steam pressure in the cylinders on the area of the piston, and also on the distance through which the pressure is exerted, or, in other words, on the stroke of the piston. Thus if we have a cylinder 17 in. in diameter and two feet stroke, and an average steam pressure of 50 lbs. per square inch, then, as the area of such a piston would be 227 square inches, the average pressure on it would be $227 \times 50 = 11{,}350$ lbs., and as each piston moves through four feet during one revolution of the wheels, the number of foot-pounds of energy exerted by it would be $11{,}350 \times 4 = 45{,}400$, and for the two cylinders of a locomotive double that amount, or 90,800 foot-pounds. If the driving-wheels are 5 ft. in diameter, their circumference will be 15.7 ft., and therefore the locomotive will move that distance on the rails during one revolution, if the wheels do not slip. The 90,800 foot-pounds of energy is therefore exerted through a distance of 15.7 ft., and therefore

$$\frac{90{,}800}{15.7} = 5{,}783 \text{ lbs.},$$

which is the force exerted through each foot that the circumference of the wheel revolves and the locomotive moves. If the wheels were only half the diameter, or $2\frac{1}{2}$ ft., then their circumference would be 7.85 ft., and the tractive power would be

$$\frac{90{,}800}{7.85} = 11{,}566 \text{ lbs.},$$

or double what it was before. It will be seen, then, that the tractive force of a locomotive is dependent upon (1) the average steam pressure in the cylinders, (2) the area of the pistons, (3)

the stroke of the pistons, and (4) the diameter of the driving-wheels.

QUESTION 405. *How is the tractive power of a locomotive calculated?*

Answer. BY MULTIPLYING TOGETHER THE AREA OF THE PISTON IN SQUARE INCHES, THE AVERAGE STEAM PRESSURE IN POUNDS PER SQUARE INCH ON THE PISTON DURING THE WHOLE STROKE, AND FOUR TIMES THE LENGTH OF THE STROKE OF THE PISTON,* AND DIVIDING THE PRODUCT BY THE CIRCUMFERENCE OF THE WHEELS. The result will be the tractive power exerted in pounds. The adhesion must, of course, always exceed the tractive force, otherwise the wheels will slip.

QUESTION. 406. *How is the locomotive made to advance by causing the wheels to revolve?*

Answer. The pressure of steam in the cylinders is exerted in one direction against the piston, and in the opposite direction against the cylinder-head, as shown in fig. 252, in which

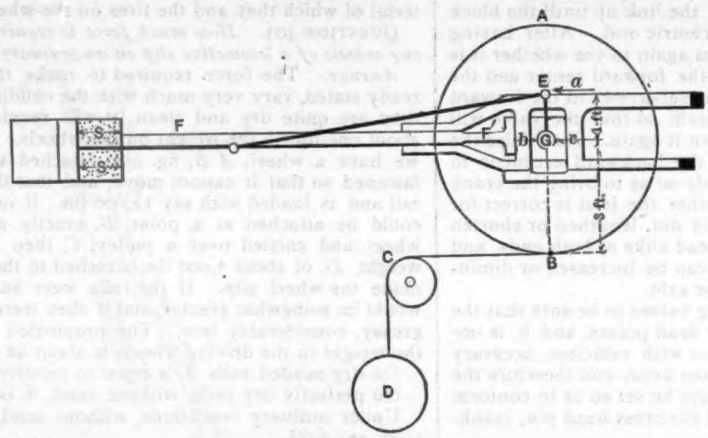


Fig. 252.

the steam is represented by the dotted shading in the back end of the cylinder, and the direction of the pressure by the darts *s s*. The pressure against the piston is communicated by the connecting-rod to the crank-pin *E*, and that on the cylinder-head is exerted on the axle through the frame *F F'*, and the direction of the two forces is indicated by the two darts, *a* and *b*. We may now regard the spokes of the wheels as acting as levers, and assume that the fulcrum is either at the center *G* of the axle, or at *B*, the point of contact of the wheel with the rail.† It may be assumed that it is at the center *G* of the axle, and for the sake of even figures that the wheel is 6 ft. in diameter and cyl-

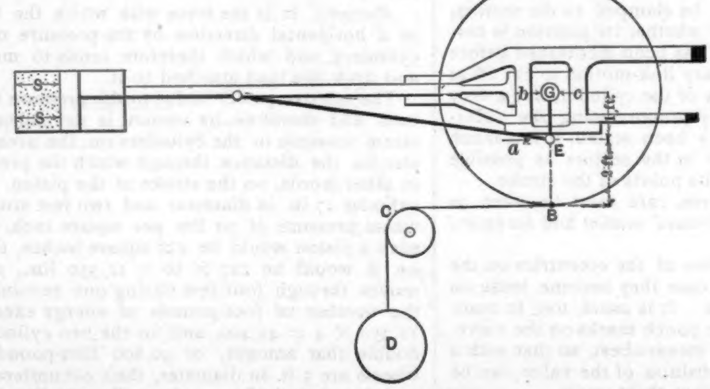


Fig. 253.

inders have 2-ft. stroke. It will also be supposed that the engine is supported, so that the wheels do not touch the rails, and that a chain or rope passing over a pulley, *C*, is attached to the wheels at *B* and with a weight at *D*. We now have a force, *a*, of say 10,000 lbs. exerted on the crank-pin, or at the end of the short arm *E G* of the lever *E G B*. As *E G* is 1 ft. and *G B* 3 ft. long, 10,000 would be balanced by

$$\frac{10{,}000 \times 1}{3} = 3{,}333 \text{ lbs.}$$

at *B*. In other words, it would require 3,333 lbs. suspended from the chain at *D* to resist the strain at *E*. But when this is the case, the pressure of the axle at the fulcrum, in the direction of the dart *c*, is equal to the pressure against the crank-pin *E* added to that exerted by the weight *D* at *B*, or 10,000 + 3,333 = 13,333 lbs.

As the pressure against the axle in the opposite direction, *b*, is only 10,000 lbs., there will be an unbalanced force of 3,333 lbs. acting in the direction of the dart *c*, and tending to move it that way. As the axle is attached to the locomotive frame, this force will, of course, have a tendency to move the whole machine, and is really the tractive force of the engine.

If, on the other hand, we regard the point of contact *B* of the wheel with the rail as a fulcrum, we have a force of 10,000 lbs. acting at *E* against a lever, *E G B*, 4 ft. long. The force which this would exert against the axle *G* would be calculated by multiplying 10,000 by the whole length of the lever, and dividing by its long arm *G B*, so that we will have

$$\frac{10{,}000 \times 4}{3} = 13{,}333 \text{ lbs.}$$

exerted at *G*; and as the pressure exerted by the steam in the cylinder in the direction of the dart *b* is only 10,000, there would be an unbalanced strain of 13,333 − 10,000 = 3,333 lbs. acting against the axle in the direction of the dart *c*, or, in other words, there is 3,333 lbs. more of force pulling the axle forward than there is pushing it backward.

When the crank-pin is below the axle, in the position shown in fig. 253, then, if the center of the axle is regarded as the fulcrum, we have a pressure of 10,000 lbs. pushing against the front cylinder-head, which is transferred to the axle by the frames, and acts in the direction of the dart *c*, and we also have a pressure acting against the crank-pin *E* in the direction of the dart *a*. If *G* is the fulcrum, the pressure which the force *a* = 10,000 lbs. would exert at *B* would be calculated by multiplying it by the short arm *G E* of the lever, and dividing by *G B* its whole length—that is,

$$\frac{10{,}000 \times 1}{3} = 3{,}333 \text{ lbs.,}$$

which is the tractive force exerted at *B*.

If, on the other hand, *B* is the fulcrum, then the force exerted in the axle *G* by the pressure of the piston on the crank-pin would be calculated by multiplying it by the length *E B* of its long arm, and dividing by its whole length *G B*, or

* This length may be taken in feet, inches, or any other measure, but in making the calculation the circumference of the wheels must be taken in the *same* measure as the stroke of the piston.

† The question whether the center of the axle or the point of contact with the rail is the fulcrum of the lever in this case has been the subject of much discussion and contention. As the word *fulcrum* means "a point about which a lever moves," it is believed that the dispute is due simply to a difference in the meaning assigned to the word fulcrum. If we regard the fulcrum as the point which is fixed in relation to the locomotive, then it is at the center of the axle; but if we refer it to the surface of the earth, then it is at the top of the rail.

$$\frac{10{,}000 \times 2}{3} = 6{,}667 \text{ lbs.}$$

exerted at G in the direction of b. But the pressure on the cylinder-head pulls against the axle G in the direction c with a force of 10,000, so that the excess of strain in the direction c will be equal to $10{,}000 - 6{,}667 = 3{,}333$ lbs.

It will be seen, then, that it is immaterial which point is regarded as the fulcrum, as the result of the calculations is exactly the same.

It must not, however, be hastily supposed from what has been said that the total pressure against the axle can be greater than its resistance to the pressure. As soon as the one exceeds the other it will move. But supposing that it requires a force equal to 3,333 lbs. to draw a train coupled to the engine, as soon as the difference between the force exerted against the axle by the piston to move it forward and that which presses it back exceeds 3,333 lbs., the locomotive will move the train. If the force exerted continues to exceed the resistance the speed of the train will be accelerated, and thus the resistance which holds the engine back and that which pushes it forward will always be equal.

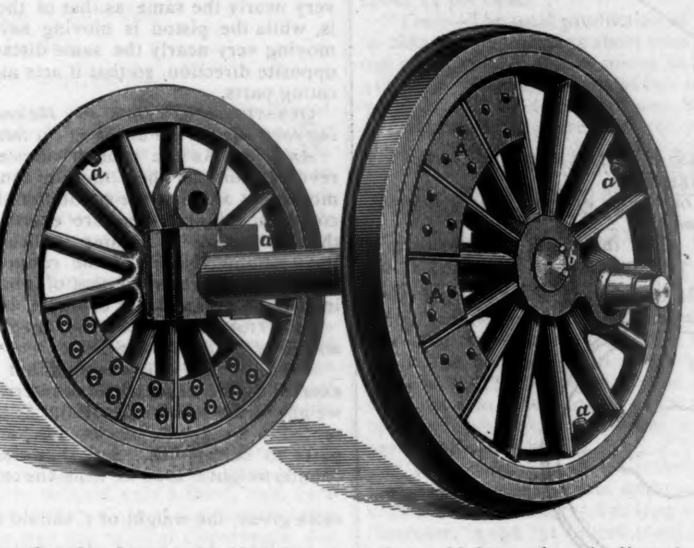


Fig. 254.

QUESTION 407. *Does the fact that the piston is working from the end of a longer lever E G' B, fig. 252, when the crank-pin is above the axle, enable the locomotive to start a heavier train than when the crank-pin is below the axle and the piston is working against a shorter lever, G E B, fig. 253?*

Answer. No; because, as has already been shown, the pressure against the axle is the same in both cases. It is, in fact, only during the forward stroke that the pressure on the crank-pin moves the engine forward. The forward pressure which is exerted by the crank-pin at the axle is then greater than that exerted against the latter in the opposite direction by the cylinder-head and frames. It is this excess of crank pressure which moves the engine and which is the tractive force during the forward stroke. During the backward stroke the piston is pushing the axle backward, and the pressure against the front cylinder-head is pulling it forward. The latter then exceeds the former, and the difference between the two is the force which moves the engine forward. As has been shown, this difference is the same in both positions of the crank, and therefore the locomotive cannot from this cause pull more when the crank is above the axle than when it is below.

CHAPTER XV.

INTERNAL DISTURBING FORCES IN THE LOCOMOTIVE.

QUESTION 408. *What are the internal disturbing forces in a locomotive?*

Answer. They are: 1, the momentum of the parts which have a reciprocating motion; 2, those due to the varying pressure of the steam on the cylinder-heads; 3, those caused by the thrust of the connecting-rods against the guide-bars; and 4, those produced by unbalanced revolving parts.

QUESTION 409. *How can the effects of these disturbing forces be neutralized?*

Answer. To some extent by putting counterweights, A A, fig. 254, in the driving-wheels opposite the crank-pins. Their motion will then be in the reverse direction to that of the parts attached to the crank-pins, and the motion of the counterweights will thus neutralize the disturbing influence of the reciprocating and other revolving parts.

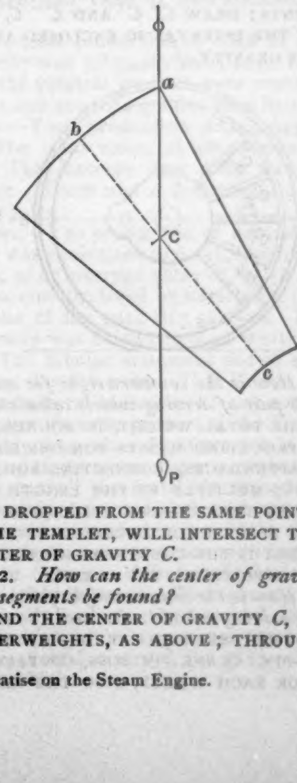
QUESTION 410. *Can the weight of these counterweights be calculated for any locomotive?*

Answer. It can probably be calculated, but it is an exceedingly complicated problem, and one about which there is much difference of opinion. The following rules are given in "Clark's Railway Machinery," and are, perhaps, sufficiently close to find a first approximation to the requisite position and weight of the counterweights; but the final adjustment should be made by trial. This can be done by suspending the locomotive by chains attached to the four corners of its frame, and setting the machinery in motion at the speed it is intended to run. By attaching a pencil to one or to each of the four corners of the frame, and arranging it so that it will mark on a horizontal fixed card, a diagram will be drawn, being usually an oval, which will show the amount and form of the oscillations. The counterweights can then be adjusted so that the diagram drawn by the pencil is reduced to the least possible size. When the adjustment is successful, the diameter of the diagram is reduced to about $\frac{1}{16}$ of an inch.* Another and simpler, but less accurate, way is to place a pail or other vessel filled with water on the front of the engine and run the locomotive on a smooth track at a high speed, and adjust the counterweights so that the least amount of water will be spilled.

QUESTION 411. *How can the center of gravity of a counterweight in one segment be found?*

Answer. BY CUTTING A WOODEN TEMPLET OF UNIFORM THICKNESS TO THE FORM OF THE SURFACE, AND FREELY SUSPENDING IT BY ONE OF THE CORNERS, a, AS IN FIG. 255; A PLUM-

Fig. 255.



MET-LINE, a P, DROPPED FROM THE SAME POINT OF SUSPENSION IN FRONT OF THE TEMPLET, WILL INTERSECT THE CENTER LINE b c AT THE CENTER OF GRAVITY C.

QUESTION 412. *How can the center of gravity of a counterweight in three segments be found?*

Answer. FIND THE CENTER OF GRAVITY C, FIG. 256, OF ONE OF THE COUNTERWEIGHTS, AS ABOVE; THROUGH C STRIKE AN

* Rankine's Treatise on the Steam Engine.

ARC FROM THE CENTER, a, OF THE WHEEL, CROSSING THE CENTER LINES OF THE OTHER SEGMENTS AT THEIR CENTERS, C' C''; DRAW C' C'' MEETING A B AT D, AND SET OFF D E, ONE-THIRD

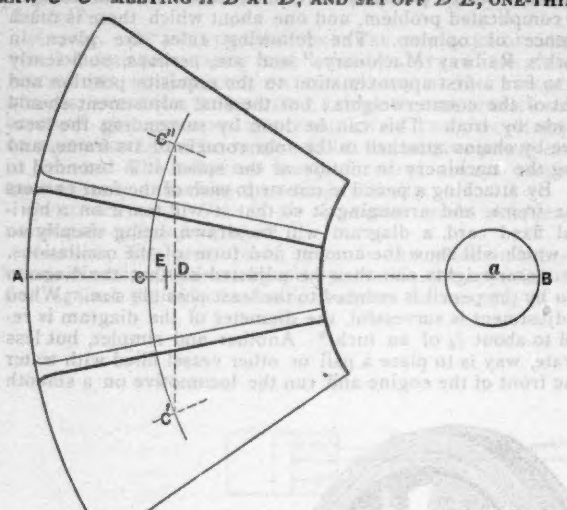


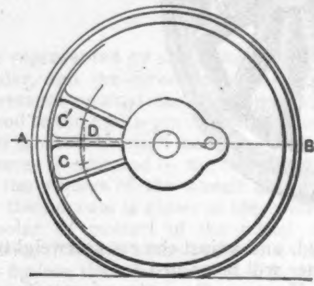
Fig. 256.

OF THE INTERVAL D C. THEN E IS THE COMMON CENTER OF GRAVITY OF THE THREE SEGMENTS.

QUESTION 413. *How can the center of gravity of a counterweight in two segments be found?*

Answer. This is required when the crank is opposite to a spoke, as in fig. 257. FIND THE CENTER OF GRAVITY, C, OF ONE SEGMENT AS BEFORE, AND BY AN ARC FIND THE OTHER CEN-

Fig. 257.

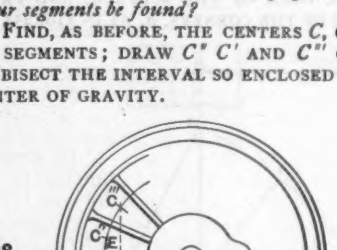


TER C'; DRAW C C', CUTTING A B AT D, WHICH IS THE COMMON CENTER OF GRAVITY.

QUESTION 414. *How can the center of gravity of a counterweight in four segments be found?*

Answer. FIND, AS BEFORE, THE CENTERS C, C', C'', C''', FIG. 258, OF THE SEGMENTS; DRAW C'' C' AND C''' C, CUTTING THE LINE A B; BISECT THE INTERVAL SO ENCLOSED AT E FOR THE COMMON CENTER OF GRAVITY.

Fig. 258.



QUESTION 415. *How is the counterweight for outside cylinder engines with a single pair of driving-wheels calculated?*

Answer. FIND THE TOTAL WEIGHT, IN POUNDS, OF THE REVOLVING AND RECIPROCATING MASSES FOR ONE SIDE—NAMELY, THE PISTON AND APPENDAGES, CONNECTING-ROD, CRANK-PIN, AND CRANK-PIN BOSS; MULTIPLY BY THE LENGTH OF CRANK IN INCHES, AND DIVIDE BY THE DISTANCE IN INCHES OF THE CENTER OF GRAVITY OF THE SPACE TO BE OCCUPIED BY THE COUNTERWEIGHT. THE RESULT IS THE COUNTERWEIGHT IN POUNDS, TO BE PLACED EXACTLY OPPOSITE TO THE CRANK.

QUESTION 416. *How is the counterweight for outside-cylinder engines with coupled driving-wheels calculated?*

Answer. FIND THE SEPARATE REVOLVING WEIGHTS, IN POUNDS, OF CRANK-PIN, CRANK-PIN BOSS, COUPLING-RODS AND CONNECTING-ROD, FOR EACH WHEEL, ALSO THE RECIPROCATING WEIGHT OF THE PISTON AND APPENDAGES, AND HALF THE CONNECTING-ROD; DIVIDE THE RECIPROCATING WEIGHT EQUALLY BETWEEN THE COUPLED WHEELS, AND ADD THE PART, SO ALLOTTED, TO THE REVOLVING WEIGHT ON EACH WHEEL; THE SUMS SO OBTAINED ARE THE WEIGHTS TO BE BALANCED AT THE SEVERAL WHEELS, FOR WHICH THE NECESSARY COUNTERWEIGHT MAY BE FOUND BY THE PRECEDING RULE.

QUESTION 417. *How do counterweights neutralize the disturbing effect of the revolving parts—that is, the crank-pins and their bosses, the back end of the main connecting-rod and the coupling-rod?*

Answer. These parts are all exactly balanced by equivalent weights placed opposite to the crank-pin, so that the wheels will be in a state of equilibrium at all points of their revolution. The horizontal motion of the reciprocating parts—that is, the piston, piston-rod, cross-head, and the front end of the main connecting-rod, may also be balanced by an equivalent weight placed opposite the crank.

QUESTION 418. *How does a revolving weight counterbalance the action of the reciprocating parts?*

Answer. It does this because its horizontal movement is very nearly the same as that of the reciprocating parts. That is, while the piston is moving say 4 in., the counterbalance is moving very nearly the same distance horizontally,* but in the opposite direction, so that it acts as counterpoise to the reciprocating parts.

QUESTION 419. *How does the counterbalance of the reciprocating parts disturb the action of the locomotive?*

Answer. As the counterbalance of the reciprocating parts revolves, and as their motion compensates for the horizontal movement alone of the counterbalance, its vertical motion is not counteracted, and therefore exerts a vertical disturbance when the locomotive is running, which has sometimes been called the "hammer-blow" of the counterbalance. Its action, however, does not resemble that of a hammer, the motion of which, in striking an anvil, for example, is stopped instantly.

QUESTION 420. *What is the effect of the unbalanced vertical motion of the counterweight?*

Answer. The only effect is that due to the centrifugal force exerted by the unbalanced counterweight. Thus, supposing the weight of the revolving parts to be balanced on the wheel represented in fig. 254 to be 300 lbs., and that of the reciprocating parts to be 275 lbs., and that the center of gravity b of the counterweight C is 20 in. from the center of the axle, then, by the rules given, the weight of C should be equal to $\frac{275 + 300 \times 12}{20}$ $= 345$ lbs. At a speed of 50 miles an hour, a wheel 5 ft. in diameter would revolve 280 times per minute. The centrifugal force of a weight of 300 lbs. at the crank-pin, as calculated by the rule given in the answer to Question 158, would be:

$$300 \times 280^2 \times 1 \times .00034 = 7,997 \text{ lbs.}$$

The centrifugal force of the counterweight would be:

$$345 \times 280^2 \times 1.666 \times .00034 = 15,327 \text{ lbs.}$$

In fig. 259, therefore, the centrifugal force which the weight at the crank-pin would exert in the direction of the dart a would be equal to 7,997 lbs., and that of the counterweight C in the opposite direction, as indicated by the dart b, would be 15,327 lbs. Therefore, as the one force is pulling upward and the other is pulling downward, the net upward force is equal to $15,327 - 7,997 = 7,330$ lbs. In fig. 260 the forces exerted in a horizontal direction, as indicated by the darts a and b, are the same as those exerted vertically in fig. 259, and therefore the net force exerted horizontally toward the left-hand side by the counterweight in this wheel, as indicated by the dart b, is again 7,330 lbs., which is just one-half the resistance due to the inertia of the reciprocating parts at the beginning of the stroke, as was shown in answer to Question 160. As the counterweights for the reciprocating parts on each side of the engine are supposed to be divided between two wheels, the net horizontal force of the two counterweights is just equal to the inertia of the reciprocating parts at the speeds on which these calculations are based. In fig. 261 the position of the crank-pin and the counterweight is reversed from that shown in fig. 259, and therefore there is a net centrifugal force of 7,330 lbs. exerted *upward.* In fig. 262 the position of the parts is in the reverse position to that shown in fig. 260, so that the difference of the centrifugal forces is exerted toward the right-hand side, and is then equal to the inertia of the reciprocating parts at the beginning of the forward stroke.

QUESTION 421. *What effect do the counterweights have on the track?*

* The angularity of the connecting-rod causes the counterbalance to move somewhat slower than the piston while the crank-pins are in front of their axles or during the front half of their revolution, and faster during the back half, as was explained in answer to Question 142.

Answer. If the whole of the revolving and reciprocating parts are counterbalanced, the centrifugal force due to the counterweights of the reciprocating parts acts alternately upward and downward during each revolution of the wheels. Thus, if a driving-wheel 5 ft. in diameter is loaded with a weight of

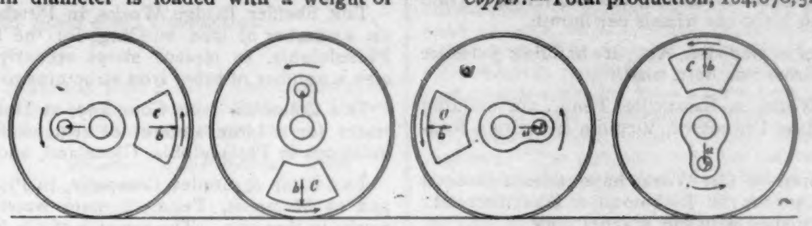


Fig. 262. Fig. 261. Fig. 260. Fig. 259.

14,000 lbs. at a speed of 50 miles under the conditions assumed above, its pressure downward, when in the position shown in fig. 259, would be :

$$14{,}000 - 7{,}330 = 6{,}670 \text{ lbs.},$$

and in the position shown in fig. 261,

$$14{,}000 + 7{,}330 = 21{,}330 \text{ lbs.}$$

At the dead points shown in figs. 260 and 262, the centrifugal forces act horizontally, and therefore have no influences either upward or downward. In moving from the position shown in fig. 259 to that shown in fig. 260, the upward pressure due to the centrifugal force gradually diminishes, and when the crank reaches the dead point this force is exerted horizontally, and produces no upward or downward pressure. In passing from the dead point to the position shown in fig. 261, the centrifugal force gradually increases in a downward direction until it reaches the position shown in fig. 261, and it then begins to diminish until it reaches the other dead point shown in fig. 262. It should be understood that the centrifugal force always acts radially, and that when the crank is in any position between those represented in figs. 259, 260, 261, and 262, the centrifugal force acts both horizontally and vertically, as was explained in answer to Question 159.

Owing to the vertical disturbing effects of the counterweights when the whole of the weight of the reciprocating parts is balanced, some engineers prefer to balance only a third, half, two-thirds, or some other fraction of the weight of the reciprocating parts of locomotives. In this way the vertical disturbance due to the inequality of the counterweights is diminished, but a horizontal disturbance is created ; but neither are then as great as one of them would be if either the whole or none of the weight of the reciprocating parts was balanced.

(TO BE CONTINUED.)

Manufactures.

Mineral Products of the United States.

FROM advance proofs of Mineral Resources of the United States for 1887, furnished us by Mr. David T. Day, Chief of the Division of Mining Statistics and Technology of the United States Geological Survey, we obtain the following summary of the values of the metallic and non-metallic mineral substances produced in the United States during the calendar year 1887 :

Metals	$250,419,283
Non-metallic mineral substances	281,637,062
	$532,056,345
Estimated value of mineral products unspecified	6,000,000
Grand total	$538,056,345

From the detailed statements given, we take the following paragraphs :

"*Iron.*—The principal statistics for 1887 were: Domestic iron ore consumed, about 11,300,000 long tons ; value at mines, $33,900,000. This is an increase over 1886 of 1,300,000 tons in quantity and $5,900,000 in value. Imported iron ore consumed, 1,194,301 long tons ; total iron ore consumed in 1887, about 12,494,301 long tons, or 1,454,868 tons more than in 1886. Pig iron made, 6,417,148 long tons ; value at furnace, $121,925,800. This is an increase over 1886 of 733,819 tons in quantity and $26,730,040 in value. Steel of all kinds produced, 3,339,071 long tons, an increase of 776,569 tons over 1886 ; value at works, $103,811,000. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $171,103,000, an increase of $28,603,000, as compared with 1886. Limestone, used as flux in the manufacture of pig iron in 1887, about 5,377,000 long tons ; value at quarry, about $3,226,200.

"*Copper.*—Total production, 184,670,524 lbs., of which 3,750,000 lbs. were made from imported pyrites. The total value was $21,052,440, at an average of 11.4 cents per lb. The estimated total consumption of copper in the United States increased by about 14 per cent.

"*Coal.*—The total production of all kinds of commercial coal in 1887 was 123,965,255 short tons (increase over 1886, 16,283,046 tons), valued at the mines at $173,530,996 (increase, $26,418,241). This may be divided into Pennsylvania anthracite, 39 506,255 short tons (increase, 2,809,780 short tons), or 35,273,442 long tons (increase, 2,508,732 long tons), valued at $79,365,244 (increase, $7,807,118) ; all other coals, including bituminous, brown coal, lignite, small lots of anthracite produced in Colorado and Arkansas, and 6,000 tons of graphitic coal mined in Rhode Island, amounting in the aggregate to 84,459,000 short tons (increase, 13,473,266 tons), valued at $94,165,752 (increase, $18,611,123).

"The colliery consumption at the individual mines varies from nothing to 8 per cent. of the total output of the mines, being greatest at special Pennsylvania anthracite mines and lowest at those bituminous mines where the coal-bed lies nearly horizontal and where no steam power or ventilating furnaces are used. The averages for the different States vary from 2.1 to 6¼ per cent., the minimum average being in the Pennsylvania bituminous and the maximum average being in the Pennsylvania anthracite region.

"The total output of the mines, including colliery consumption, was: Pennsylvania anthracite, 37,578,747 long tons (increase over 1886, 2,725,670 long tons), or 42,088,197 short tons (increase, 3,052,751 short tons) ; all other coals, 87,837,360 short tons (increase, 14,129,403 tons), making the total output of all coals from mines in the United States, exclusive of slack coal thrown on the dumps, 129,925,557 short tons (increase, 17,182,154 tons), valued as follows : Anthracite, $84,552,181 (increase, $8,433,061) ; bituminous, $97,939,656 (increase, $19,458,600) ; total value, $182,491,837 (increase, $27,891, 661). The above figures show a notable increase in 1887 over 1886 in the aggregate output and value of both anthracite and bituminous coal.

"*Coke.*—The total production of coke in the United States for the year 1887 was 7,857,487 short tons, valued at $15,723,574. This is the greatest product ever reached in the United States, being 1,022,419 tons greater than in 1886.

"*Petroleum.*—Total production, 28,249,543 barrels of 42 gallons each. The total value, at an average of 60 cents, was $16,949,726. The increase over 1886 was very slight, only 139,428 barrels. There was a decrease of 11½ cents per barrel in the average price.

"*Natural gas.*—The production of natural gas in the United States in 1887 was equivalent to 9,055,000 short tons of coal displaced. This, at an average value of $1.50 a ton, would make the value of the coal displaced by natural gas (which is the measure of the value of the gas), $13,582,500. In 1886 the corresponding quantity was 6,353,000 tons, worth $9,847,150.

"*Totals.*—The tabular statement shows an aggregate value of $538,056,345 for the year. This is the largest total ever reached by the mineral industries of any country. It is nearly $73,000,000 more than the product of the United States in 1886 and considerably more than $100,000,000 in excess of the year 1885. Of many items which have contributed to this result, it may be noted that all the metals increased in quantity except gold and the minor metal, nickel, and nearly all increased in price. The significance of this is seen in the increase in production of the fuels necessary for reducing these metals and preparing them for use. All of these fuels, including natural gas, show a marked increase. The increased value of building stone is principally due to a more careful canvass of this industry than has been possible in previous years. It is not probable that the great total recorded for 1887 will be equaled in the present year, 1888."

Cars.

THE Ensign Manufacturing Company at Huntington, W. Va., has recently closed a contract to furnish the Baltimore & Ohio Railroad Company with 2,500 car wheels per month.

THE Elliot Car Works at Gadsden, Ala., are building 300 more cars for the Alabama Great Southern road.

THE Southern Car Works at Knoxville, Tenn., are building 300 coal cars for the East Tennessee, Virginia & Georgia Railroad.

THE new South Baltimore Car Works have taken a contract for building 500 box cars for the Richmond & Danville road; these cars are to be furnished with the Wagner door.

THE United States Rolling Stock Company is working steadily on the enlargement of its new car works at Anniston, Ala., the machine shops and the main building being now completed. Three new steam-hammers are being erected in the smith-shop, and work has been begun on a wood-working shop.

THE Centropolis Car & Machine Works is the name of a corporation which purposes building extensive car shops at Centropolis, a suburb of Kansas City, Mo. The works will cover 10 acres of land which has been bought for the purpose, and very extensive buildings have been begun. The new shops will build not only freight cars, but street and passenger cars.

Locomotives.

THE Rogers Locomotive Works, Paterson, N. J., have among other contracts an order for 30 locomotives for the St. Paul, Minneapolis & Manitoba Railroad.

THE Cooke Locomotive Works, Paterson, N. J., have recently taken a contract for 25 freight engines for the Chicago, St. Paul & Kansas City road.

THE Schenectady Locomotive Works are building 26 locomotives for the Chicago, St. Paul, Minneapolis & Omaha Railroad.

THE Rhode Island Locomotive Works, in Providence, have contracts for the Chicago, St. Paul & Kansas City; for the Western & Atlantic and for the Minneapolis, St. Paul & Sault St. Marie road.

THE Manchester Locomotive Works, Manchester, N. H., recently delivered to the New York, Providence & Boston Railroad two locomotives intended to run the fast passenger trains on that road. These engines burn soft coal, have boilers 54 in. diameter of barrel, with 206 tubes 2 in. diameter, that are intended to carry a working pressure of 175 lbs. The cylinders are 17 in. in diameter and 24 in. stroke, and the driving-wheels are 68 in. in diameter.

THE Baldwin Locomotive Works, in Philadelphia, recently delivered to the New York, New Haven & Hartford Railroad six very heavy locomotives, intended to run the fast passenger trains between New York and New Haven. The same works are building some consolidation engines for the New Jersey Central, and are filling an order for 50 locomotives for the Philadelphia & Reading road.

THE Dickson Manufacturing Company in Scranton, Pa., is building 16 engines for the Central Railroad of Georgia, and is also building several engines with the Wootten fire-box for the Delaware, Lackawanna & Western road.

Manufacturing Notes.

MESSRS. T. WILLIAM HARRIS & COMPANY, 44 Broadway, New York, have been awarded the contract for laying mains for fuel gas at Tacony. This is the beginning of a system intended to furnish the city of Philadelphia with fuel gas, generated on the Loomis system, which, it is claimed, furnishes a very cheap and economical fuel. The same firm has recently been retained as consulting engineers by the Harvard Woolen Mill Company, and are now arranging a plan for disposing of the waste and wash of the mill in a satisfactory and proper manner.

ONE of the Mills in the Elliptic Department of the A. French Spring Company, in Pittsburgh, was damaged by fire August 15, but there has been no delay in filling orders, as the company has a duplicate mill.

THE Union Bridge Company, New York, has the contract for several steel bridges which will be required in the work of depressing the tracks of the New York Central & Hudson River road in New York City north of the Harlem River.

THE Sheffler Bridge Works, in Pittsburgh, are now putting up a number of iron buildings for the Disston Saw Works in Philadelphia, to replace shops recently burned. They have also a number of other iron structures to build.

THE Columbia Iron Company, at Uniontown, Pa., has contracts for a large amount of structural iron work, including buildings in Philadelphia, Cleveland, and Washington.

THE Riter & Conley Company, in Pittsburgh, recently shipped to Memphis, Tenn., a steel water-tower, for the water works in that city. The tower is 160 ft. high, 26 ft. in diameter, and will be secured to the stone foundation by 20 in. I-beams.

THE Chester Rolling Mill Company, in Chester, Pa., has let a contract for building a new Bessemeer steel plant, with a capacity of 2,500 tons per week. This plant will be erected by J. P. Withrow & Company, of Pittsburgh, Pa.

THE Westinghouse Air Brake Company has awarded the contract for the foundation work of its new works at Wilmerding, on the Pennsylvania Railroad, near Pittsburgh, and the contractors will soon begin work. Among the structures to be built are the machine-shop, which is to be 500×250 ft.; the foundry, 500×300 ft.; the boiler-house, 160×80 ft., and the blacksmith-shop, 250×150 ft. It is estimated that the cost of the plant will reach nearly $1,000,000. A town is to be laid out.

Marine Engineering.

A LARGE steamer was launched from Reybolt & Walter's yard at Sheboygan, Wis., on July 28. It is a wooden vessel 276 ft. keel, 299 ft. over all, 40 ft. beam, and 26 ft. molded depth. The engine is a triple expansion, with cylinders 20, 32, and 54 in. diameter, and 42 in. stroke. She is intended to carry grain, and will run from Milwaukee.

THE side-wheel steamboat *Puritan*, built for the Old Colony Steamboat Company, was launched July 25 from the yard of the Delaware River Iron Ship Building Company, at Chester, Pa. The *Puritan's* hull is all steel, and her dimensions are 404 ft. on the water line, 420 ft. long over all, 20½ ft. hold, 52 ft. beam, and 91 ft. breadth over guards. The hull is to be taken to New York, where the upper works will be put on and where the engine is to be built, and the boat will be ready to take her place in the line next season. The engine of the *Puritan*, which is built by the W. & A. Fletcher Company in New York, will be a compound beam engine, having a high-pressure cylinder 75 in. diameter and 9 ft. stroke and a low-pressure cylinder 111 in. diameter and 14 ft. stroke. She is somewhat larger than the *Pilgrim*, built for the same line a few years ago, and will differ from her in having a compound engine.

THE *Marine Journal* publishes the following list of American steamers which will answer the requirements of the Naval Reserve Bill in regard to speed:

Vessel.	Hailing Port.	Tonnage.	Speed.
Newport	New York	2,735	17.9
City of Augusta	Savannah	2,870	16.5
City of Puebla	San Francisco	2,624	16.5
Queen of the Pacific	Portland, Ore	2,728	16.5
Alameda	Philadelphia.	3,158	16.5
Mariposa	San Francisco	3,158	16.5
State of California	San Francisco	2 266	16
Allianca	New York	2 985	16
Louisiana	New York	2,840	16
Ohio	Philadelphia	3,126	15.6
Saratoga	New York	2,426	15.4
City of Alexandria	New York	2,480	15.4
Nacoochee	Savannah	2,680	15.4
Chattahoochee	New York	2,676	15.4
Roanoke	New York	2,354	15.4
Excelsior	New York	3,264	15.4
Alamo	New York	2,943	15.4
Lampasas	New York	2,943	15.4
El Paso	New York	3,531	15.4
El Dorado	New York	3,531	15.4
H. F. Dimock	Boston	2,625	15.4
Herman Winter	Boston	2,625	15.4
Seminole	New York	2,557	15.4
El Monte	New York	3,531	15.4
San Pedro	New York	3,119	15 4
San Pablo	New York	4,064	15.4
Cherokee	New York	2,557	15
Santa Rosa	New York	2,417	15

The Navy Department has thus accredited 28 American steamers of from 2,400 to 4,000 tons with a sea speed of 15 knots or over, and from these vessels, should the Naval Reserve

Bill finally pass, will be made the selection of the ships which will be called into use as cruisers in case of emergency.

Steel and Steel Rail Production.

THE *Bulletin* of the American Iron & Steel Association gives the production of Bessemer steel and steel rails in the United States for the first half of 1888 as follows, in net tons:

	Bessemer.	Clapp-Griffiths.	Total.
Steel ingots	1,348,218	36,070	1,384,288
Steel rails	775,261	......	775,261

The totals for the last half of 1887 were 1,650,785 tons of ingots and 1,146,117 tons of rails; showing a decrease of 18½ per cent. in ingots and 32¼ per cent. in rails.

The *Bulletin* says: "These figures do not include a few thousand tons of Bessemer steel rails rolled in each period in iron rolling mills from purchased blooms. The production of Bessemer steel rails in the first half of 1888 was reduced much more than that of ingots, indicating an increased use of Bessemer steel thus far this year for miscellaneous purposes of nearly 100,000 gross tons over the last half of 1887."

Proceedings of Societies.

American Society of Civil Engineers.

THE Board of Direction of this Society invites professional papers and communications on subjects of engineering interest from all persons, whether members of this Society or not. These papers and communications will be accepted for publication in the *Transactions* of the Society, subject to the regular rules prescribed by the Society laws, which provide for a proper editorial supervision, and for the exclusion of old matter readily found elsewhere, of matter specially intended to advocate personal interests, of matter carelessly prepared or controverting established facts, and of matter purely speculative or foreign to the purposes of the Society. Discussion is also invited from all persons interested in the papers presented to the Society, such discussion to be, of course, subject to the same editorial rules.

The *Transactions* of the Society will be sent to any subscriber at the rate of $10 per year; and to clubs of ten or more, when ordered through the Secretary of an engineering or technical society or club, who will be responsible for the payment, at 25 per cent. discount.

Engineers' Society of Western Pennsylvania.

AT the last meeting of the season, in Pittsburgh, June 19, B. Speer, R. B. Lean, C. H. Davis, A. C. Cunningham, E. H. Kenyon, A. F. Keating, Frank J. Kimball, William Bakewell, and A. L. Reineman were elected members.

Mr. W. E. Koch's paper on Open-Hearth Steel was discussed by Messrs. Stafford, Bailey, Reese, A. E. Hunt, Roberts, Rodd, Brashear, and Koch.

A communication from the Engineers' Club of Kansas City, asking co-operation in the effort to bring about Government inspection of bridges, was received, and, together with a request from the Western Society of Engineers, was referred to a special committee, consisting of A. E. Hunt, Thomas Rodd, Charles Davis, G. Lindenthal, and F. C. Osborn.

A resolution commending the establishment of a technical school in connection with the Western University of Pennsylvania was adopted.

The death of David A. Smith was announced, and a committee appointed to report at next meeting.

Engineers' Club of Cincinnati.

AT the regular meeting, July 11, there were 17 new members elected, making the total number 57.

Mr. J. Foster Crowell led a discussion on Skew Arches, maintaining that the difficulty and (when brick is largely used) the expense of skew construction are usually overestimated by engineers.

He described minutely a skew arch recently built by him near Oakley, O., to carry a double-track railway through the embankment of another railway. The angle of skew was 47½°; span of arch, 28 ft.; length, 80 ft., with 40 ft. wing walls at either end. The body of arch was of ordinary brick laid in spiral courses conforming to guide lines marked on the lagging, each course springing from a skew-back of cut stone. The faces of the arch were of stone, the beds of each stone being cut to helicoidal surfaces. No specially skilled stone-cutters were required. The structure cost the railroad but 5 per cent. more than the same amount of plain first-class masonry would have cost at contract price, while the saving in amount of masonry secured by the adoption of skew construction was 15 per cent.

As an interesting incident, Mr. Crowell mentioned that during the ten months occupied in constructing this arch beneath the Cincinnati, Washington & Baltimore Railroad, not one of the very numerous daily trains on that road was delayed.

Association of American Railway Accounting Officers.

THIS Association was fully organized at a meeting held in New York, July 25 and 26, when a constitution was adopted, and the following officers were elected: President, Marshall M. Kirkman, Chicago & Northwestern; First Vice-President, Max Riebenack, Pennsylvania Railroad; Second Vice-President, G. L. Lansing, Southern Pacific Company; Secretary, C. G. Phillips, Chicago; Executive Committee, J. P. Whitehead, Cushman Quarrier, S. M. Williams, D. A. Waterman, Stephen Little, S. B. Willey, and Chauncey Kelsey.

The object of the Association is to secure uniformity in accounts, prompt adjustment of claims, and, by mutual discussion, improved methods of accounting.

Addresses were delivered before the Association as follows—viz.:

Joint Through Freight Accounts, T. J. Hyman, Auditor and General Accountant Wisconsin Central Associated Lines.

The Accounting Department as a Factor in the Management of Railroads, S. M. Williams, Comptroller Central Railroad of New Jersey.

The Settlement at Junction Points of the Charges on Prepaid Shipments, Way-billed *via* Fast Freight Lines, and upon which Bills a Division of Revenue is Stated, J. P. Curry, Auditor New York, Chicago & St. Louis Railroad.

The Coupon Accounts of Railroads, M. Riebenack, Assistant Comptroller Pennsylvania Railroad.

The suggestions and recommendations contained in these suggestions were referred to the Executive Committee, and will at a future meeting come before the Association for definite action. In the mean time, the addresses will be printed in the report of the proceedings and circulated among all interested. More than 100 roads are already represented in the Association, and the Secretary will be pleased to receive applications for membership from those eligible.

Master Car and Locomotive Painters' Association.

THE nineteenth annual meeting of this Association will be held in Cleveland O., beginning on Wednesday, September 12, at 10 A.M. A general invitation is given to foremen car and locomotive painters throughout the United States and Canada to be present at the convention. The programme includes papers and discussions on a number of subjects of practical importance.

Master Mechanics' Association.

SECRETARY ANGUS SINCLAIR has issued the following list of the committees appointed by President Setchel to carry on the work of investigation and other business during the ensuing year:

1. *Purification, or Softening, of Feed Water:* Herbert Hackney, John Player, W. T. Small.
2. *Tires. Advantage, or otherwise, of Using Thick Tires:* J. W. Stokes, C. E. Smart, Henry Schlacks.
3. *Exhaust Pipes and Nozzles; Best Form and Size in Proportion to Cylinder:* C. F. Thomas, A. W. Gibbs, George D. Harris.

4. *Driving and Engine Truck Boxes; Best Form and Material, including Journal-bearing and Method of Fastening same in Box:* William Buchanan, John W. Cloud, J. M. Boon.

5. *Boiler Covering; Best Method and Material to Prevent Radiation of Heat:* G. W. Stevens, John Mackenzie, T. B. Twombly.

6. *Driver Brakes; Best Manner of Applying, including Best Form and Material for Driving Brake-shoes:* Charles Blackwell, H. D. Gordon, W. H. Thomas.

7. *Best Proportion of Grate and Flue Area:* J. Davis Barnett, G. W. Ettenger, Philip Wallis.

8. *Foundation Ring for Boiler-leg; Best Form, and Advisability of Double Riveting:* J. N. Lauder, W. J. Robertson, Harry Tandy.

9. *Water Space Surrounding Fire-box; is it usually Large enough for Free Circulation?* John Hickey, J. N. Barr, R. W. Bushnell.

10. *Magnetic Influence of Iron and Steel in Locomotives on the Watches of Engine-runners:* T. W. Gentry, James Meehan, Harvey Middleton.

Paper to be read by Coleman Sellers, Associate Member.

Committees to prepare Obituaries of Deceased Members: Of Charles T. Parry: E. H. Williams, Isaac Dripps, H. D. Garrett. *Of W. H. Morrow:* W. L. Austin, L. M. Ames, L. B. Paxson. *Of Robert Curtis:* E. B. Wall, W. W. Reynolds, Leroy Kells. *Of J. O. D. Lilly:* Reuben Wells, William Swanston, John McKenna.

Committees are urged to begin the work assigned them as early as possible, in order that valuable reports may be prepared in good season for the next Convention.

American Institute of Mining Engineers.

THE following circular has been issued by the Secretary, Professor R. W. Raymond, from his office, No. 13 Burling Slip, New York:

"I. The Fifty-second Meeting of the Institute will be held at Buffalo, N. Y., beginning on Tuesday evening, October 2, 1888. Further particulars will be given in a later circular. Members proposing to present papers at this meeting should notify the Secretary of the Institute as early as possible, stating the nature of the proposed papers."

New England Roadmasters' Association.

THE sixth annual meeting was held in Boston, August 15 and 16. On the first day the proceedings opened with an address from the retiring President, Mr. J. S. Lane, and the usual routine business was disposed of. The following officers were elected for the ensuing year: President, J. R. Patch; Vice-President, G. W. Bishop; Chaplain, E. Newcomb; Secretary, W. F. Ellis; Treasurer, George Nevens; Executive Committee, F. C. Clark, J. W. Shanks, and L. H. Perkins.

Reports were presented by different committees on Highway Crossings and the Best Method of Making Them; on Steel Rails and Rail Joints; on Ballast; on Ties and on Hand Cars. These reports were thoroughly discussed by the members present.

The meeting closed by an excursion trip down the harbor. The attendance was not large, the time chosen for the meeting being, unfortunately, in the busy season for members.

American Association for the Advancement of Science.

THE thirty-seventh annual meeting began in Cleveland, O., August 15. The new President, Major J. W. Powell, took the chair and made a brief address. Dr. Julius Pohlman was chosen General Secretary. The annual report showed 113 new members; 137 papers had been filed for reading and discussion at this meeting.

In the afternoon the Association divided into eight sections for the reading and discussion of papers, a number of which were disposed of, the most important being that of Professor George H. Cook, of New Jersey, on the International Geological Congress.

In the evening there was a short session, which was followed by a general reception to the members.

The meeting continued through the week, a large number of papers being read in the different sections. Two general meetings were also held.

OBITUARY.

COLONEL B. W. FROBEL, who died in Monticello, Ga., July 22, aged 56 years, was born in Alexandria, Va., and graduated from West Point, serving for some time in the Army. During the War he was in the Confederate service, and since its close has been actively engaged as a civil engineer. For two years past he had been Chief Engineer of the Macon & Covington Railroad.

JAMES T. CLARK, who died in Milwaukee, Wis., July 21, aged 56 years, was for nearly 20 years on the Chicago, Burlington & Quincy in various subordinate positions. In 1873 he went to the Union Pacific as Division Superintendent, and four years later was appointed General Superintendent of the road. In 1882 he was appointed General Superintendent of the Chicago, Milwaukee & St. Paul, and held that position until his death.

P. D. COOPER, who died in Elkhart, Ind., July 25, aged 54 years, was for many years employed on the Lake Shore road, rising gradually from the position of station agent to be Assistant General Superintendent. In 1873 he was appointed General Superintendent, and later General Manager of the New York, Pennsylvania & Ohio Railroad, but retired in 1882 on account of ill-health, and has not since been engaged in active work.

GENERAL WILLIAMS C. WICKHAM, who died in Richmond, Va., July 23, aged 67 years, was for many years engaged on the Chesapeake & Ohio Railroad. As President at first he actively pushed forward the work of building the road, and when the company was reorganized he had charge of its operation as Vice-President and General Manager. For some months past he had been Receiver. General Wickham was in the Confederate cavalry service during the War, and served several terms in the Virginia Legislature.

COLONEL JAMES N. SMITH, who died in Litchfield, Conn., July 31, was for a number of years a member of the well-known contracting firm of Smith & Ripley, who built the Fourth Avenue Improvement on the Harlem Railroad in New York, and also had large contracts on the Union Pacific, the New York, Chicago & St. Louis, and many other roads. For several years past Colonel Smith has lived in Brooklyn, but has spent most of his time in the South, where he was largely interested in building railroads in Georgia and Florida.

JACOB FRENCH SHARP, who died in Wilmington, Del., August 2, aged 73, was born in Hunterdon County, N. J. In early life he was a carpenter and afterward a bridge-builder, and built a large number of wooden bridges, including several important railroad structures. About 1840 he settled in Wilmington, and engaged in the business of building cars, founding with Mr. Jackson the works that have since become so widely known under the name of the Jackson & Sharp Company. Mr. Sharp retired from active business some 12 or 14 years ago, although still retaining an interest in the company.

CHARLES CROCKER, who died in Monterey, Cal., August 14, aged 66 years, was born in Troy, N. Y., and went to California in 1849, where he engaged in business in Sacramento. In 1860 he joined with C. P. Huntington, Mark Hopkins, and Leland Stanford in building the Central Pacific Railroad. In 1862 he was made General Superintendent of the road and later Vice-President. In 1871 he was chosen President of the Southern Pacific Company, and he was the chief agent later in consolidating the property of the two companies. For some years past Mr. Crocker had not taken an active part in the management of his roads, but spent much of his time in New York. His death was the result of injuries received from being thrown out of a carriage over two years ago. Mr. Crocker leaves a very large fortune.

COLONEL JAMES STEVENSON, who died in New York, July 20, aged 48 years, was for many years connected with the United States Geological Survey as Ethnologist. At an early age he showed a strong taste for ethnology, and before his fifteenth year went beyond the frontier and studied the characteristics of

several Indian tribes. In his sixteenth year he became engaged in the Government geological work, then being carried on under Professor Hayden, the head of the Geological Survey. His researches were interrupted by the War. Immediately thereafter he began a series of explorations. When Major J. W. Powell was placed at the head of the Geological Survey, he appointed Colonel Stevenson his Executive Officer. During recent years, however, Colonel Stevenson, at his own request, has been detailed on special ethnological research in connection with the Smithsonian Institution.

PROFESSOR HENRY CARVILL LEWIS, who died in Manchester, England, July 31, aged 35 years, was born in Philadelphia, and was graduated at the University of Pennsylvania in 1873; in 1879 he joined the State Geological Survey as a volunteer, and first investigated the surface geology of Southern Pennsylvania, after which he studied the glacial phenomena of the northern part of the State, and traced the great terminal moraine from New Jersey to the Ohio frontier. He furnished numerous papers on the geology and mineralogy of Pennsylvania to the *Proceedings* of the Philadelphia Academy of Natural Sciences. He was elected Professor of Mineralogy in the Academy of Natural Sciences in 1880, and to the chair of geology in Harvard College in 1883. These positions he held at the time of his death. Since 1885 he had been engaged in geological studies in Europe, working at microscopic petrology in the University of Heidelberg, and had completed a map of the separate ancient glaciers and ice-sheets of England, Wales, and Ireland. Professor Lewis was a member of a number of scientific societies in the United States and Europe, and contributed to their *Proceedings* and to other scientific periodicals, including the *American Naturalist*, of the mineralogical department of which he was for some time editor.

LIEUTENANT-COLONEL WALTER MCFARLAND, United States Engineer, who died in New London, Conn., July 22, aged 52 years, was born in New Jersey, and was appointed from New York to the West Point Military Academy, where he was graduated in 1860, ranking first in his class. He was brevetted Second Lieutenant in the Corps of Engineers in July of that year, and was detailed as Assistant Engineer in the construction of the defenses of the approaches to New Orleans. Afterward he was engaged on the fortifications at Key West, Fla., and from April 16, 1861, till the following September as Assistant Engineer in the defense of Fort Pickens, Fla. With the rank of First Lieutenant he then took part in the naval expedition for constructing the defenses at the heads of the passes of the Mississippi River. Afterward he superintended engineering work at Key West and Fort Jefferson, Fla., and was Assistant Engineer in military operations near Charleston, S. C. He was made a Captain in the Engineer Corps, 1863, and till 1865 he had charge of the defenses at Mobile, as Chief Engineer of the Sixteenth Army Corps. During a part of 1865 he served as Assistant Adjutant-General of the Thirteenth Army Corps. In March, 1867, he was promoted to the rank of Major, and since March, 1884, he had been Lieutenant-Colonel of Engineers. Since the retirement of General John Newton, Colonel McFarland has been in charge of the improvements at Hell Gate. He bore a high reputation as a military engineer.

PERSONALS.

G. N. MILLER, of St. Paul, Minn., has been appointed Superintendent of Sewers at Helena, Mont.

W. D. MINTON has been appointed Master Car-Builder of the Texas & Pacific Railroad.

M. T. CARSON has been appointed Superintendent of Motive Power of the Mobile & Ohio Railroad.

ROBINS FLEMING, C.E., has resigned the position of Instructor of Civil Engineering in Lafayette College, Easton, Pa.

J. B. MOLL has been appointed General Roadmaster of the Chicago, Milwaukee & St. Paul Railway, with office in Milwaukee.

T. A. PHILLIPS has been appointed General Superintendent of Transportation of the East Tennessee, Virginia & Georgia Railroad.

J. F. HINCKLEY has resigned his position as Chief Engineer of the St. Louis, Arkansas & Texas road, and will take a trip to Europe.

W. G. CLARK has been appointed General Superintendent of the Northern Division of the Mexican National Railroad, with office at Laredo, Tex.

A. J. EARLING is now General Superintendent of the Chicago, Milwaukee & St. Paul Railway, succeeding the late J. T. Clark. Mr. Earling has been connected with the road for more than 20 years.

CHARLES MACDONALD, of the Union Bridge Company, recently returned from his trip to Australia, where he has been superintending the work of putting down the foundations for the great Hawkesbury Bridge.

W. C. VAN HORNE, who succeeds SIR GEORGE STEPHEN as President of the Canadian Pacific Company, has been Vice-President for some time, and had previously served as General Superintendent of the Chicago, Milwaukee & St. Paul, the Chicago & Alton, and several other roads.

FRANK M. WILDER, recently General Manager of the Safety Car Heating & Lighting Company of New York, has accepted the position of Assistant to the President of the United States Rolling Stock Company, with headquarters at New York. He will have general supervision of all the shops of the company.

J. R. SHALER has resigned his position as General Superintendent of the New York, Pennsylvania & Ohio road, and the office has been abolished. Mr. Shaler has been General Superintendent for two years, and was previously Superintendent of the Eastern Division. The resignation took effect August 1.

WILLIAM R. BILLINGS, formerly Superintendent of the Taunton Water-Works, and more recently connected with the Chapman Valve Manufacturing Company, of Boston, has been chosen Agent and Treasurer of the Taunton Locomotive Manufacturing Company, of Taunton, Mass., and assumed the duties of his new office August 1.

COLONEL GEORGE W. PERKINS, who recently celebrated his 100th birthday at Norwich, Conn., has been for 53 years—from its first organization—an officer of the Norwich & Worcester Railroad Company. He has always been an active man, and is still able to attend to business, in spite of his great age. Colonel Perkins received many presents and other attentions on his birthday.

THE following promotions in the Engineer Corps have been made, consequent on the appointment of Colonel Casey to be Chief of Engineers: LIEUTENANT-COLONEL ORLANDO M. POE to be Colonel; MAJOR SAMUEL M. MANSFIELD and MAJOR WILLIAM R. KING to be Lieutenant-Colonels; CAPTAIN JAMES B. QUINN to be Major; FIRST LIEUTENANT FREDERICK V. ABBOTT to be Captain; SECOND LIEUTENANT WILLIAM E. CRAIGHILL to be First Lieutenant.

J. H. SETCHEL resigned his position as Superintendent of the Brooks Locomotive Works at Dunkirk, N. Y., on August 1. He will take a well-earned rest before entering upon any new work. In a circular stating Mr. Setchel's resignation, the Brooks Locomotive Works say:

"In making this announcement the Brooks Locomotive works wish to express their high appreciation of the mechanical ability and faithful services rendered by Mr. Setchel while in charge of the construction departments of their works."

THE venerable CAPTAIN JOHN ERICSSON passed his eighty-fifth birthday at his house in Beach Street, New York, on July 31. The day was spent in his usual occupations, but in the morning he received a call from Consul-General Bors, as representative of the Swedish Government in New York, and in the evening about 400 members of the United Scandinavian Singing Societies serenaded him, singing Swedish national and other songs. Captain Ericsson is in excellent health, and is still a steady and persistent worker, but lives very quietly.

THE Croton Aqueduct Commission, appointed by the Mayor of New York under the new law, consists of GENERAL JAMES G. DUANE, FRANCIS M. SCOTT, JOHN J. TUCKER, and WALTER HOWE. General Duane has just been retired from the office of Chief of Engineers, U.S.A., having reached the limit of age for active service prescribed by law; he is, however, still an active man, and is an engineer of high reputation. He had charge of the building of the Washington Aqueduct some years ago. Mr. Scott is a lawyer, and is very familiar with city business, having been Assistant Corporation Counsel. Mr. Tucker is a well-known builder, who has erected some of the largest buildings in the city, and Mr. Howe is a citizen of wide acquaintance and excellent reputation, both for his integrity and his public spirit. It would be a very difficult matter to pick out a better commission.

NOTES AND NEWS.

Oil Tank Steamers in England.—Another petroleum tank steamer was launched recently from the shipyard of Messrs. Armstrong, Mitchell & Company. The new vessel is called the *Oevelgonne*, and will carry in her tanks 3,800 tons, or over 1,000,000 gallons of petroleum each trip. Two powerful Worthington pumps and a complete installation of piping will enable the oil to be pumped in or out of any compartment, or from one to the other. Under the old system of transporting the oil in barrels many days would be needed to barrel and stow a million gallons of oil; whereas in these new tank steamers it is simply a question of a few hours, requiring practically no labor whatever.

Baltimore & Ohio Employés' Relief Association.—The June statement of this Association shows the following payments for the month:

	Number.	Amount.
Accidental deaths	4	$4,000
Accidental injuries	300	4,054
Surgical expenses	225	1,089
Natural deaths	9	4,802
Natural sickness	500	8,111
Total	1,038	$22,056

The total number of payments made since the Association was organized in 1880 has been 78,079, and the total amount has been $1,768,924.

Coal Industry of Russia.—A report from the British Consul at Taganrog on the coal industry of Southern Russia has just been laid before Parliament. The annual output at present exceeds 1,600,000 tons, of which about 1,300,000 tons are carried by railroad, but it is calculated that nearly 3,000,000 tons will be available for transport during the present year, besides the quantity consumed in the neighborhood of the mines. A long list is given of the quantities sent away by the various railroads and consumed in different undertakings. The increased sale of Donetz coal is principally due to the duty on foreign coal, the prices of which in 1887 were unremunerative, owing to capricious railroad rates, absence of shipping facilities, and the great expense of landing coal at such ports as Taganrog and Mariapol. Mr. Wagstaff thinks English colliery owners have no need to fear their Russian rivals in foreign markets.

A Railroad to Soukhum-Kale.—The Russian Government contemplates constructing a railroad shortly to Soukhum-Kale. This port lies in somewhat an isolated position, and it was in order to remove this that a military road was recently constructed to it across the Caucasus ridge from Ekaterinadar. It is now proposed to run a branch line to the port from the Transcaucasian Railroad via Novo-Senaki. This would be 79 miles long, and could be accomplished with very few engineering difficulties. The climate of Soukhum-Kale is so good that the place is used as a sanitary station for the Caucasian army. The construction of the line would give a new impulse to the port by rendering it an outport for Transcaucasian produce. It would also open up much of the country to colonization, and the authorities are now disposed to take this question vigorously in hand, in connection with the proposed railroad.

Developing the Coal Mines in the Argentine Republic.—The Legislative Assembly of the Argentine Republic, in order to encourage the development of the coal-mining industry, has approved a proposal made by a private company by which the Government guarantees to the company undertaking to work the coal mines of Rioja an interest of 5 per cent. on the capital invested for 15 years; the company to invest a capital of $2,000,000, the guarantee of the Government to begin from the day that the railway connection is established or from the day when actual work begins in the mines. If the work at the mines is stopped for four months, the Government guarantee is withdrawn. If the company's profit reaches 10 per cent. of the capital invested, all the surplus profit is to be paid to the Government until all the guarantee disbursement made by the Government has been paid back, together with 5 per cent. yearly interest on it.

A Railroad in Persia.—According to the Moscow papers, the first line of railroad in Persia was opened about June 20. It has been constructed by a Belgian company, and extends from Teheran to Shag-AbdulA-zima, a distance of about 10 miles.

The construction of this line was surrounded by enormous difficulties, arising chiefly from the transport of material into Persia. Each mile cost nearly $36,000, and the whole cost more than $400,000. The larger portion of the material was brought through the Caucasus and Russia from Belgium, and the duty paid amounted to $40,000. It may be taken for granted that this short section of railroad cannot possibly pay the company, but the question of securing concessions for the construction of the entire line from the Persian Gulf to the Caspian Sea is conditioned on the success of this portion of the railroad. The object of beginning construction at Teheran instead of the Caspian was doubtless to enable the Shah to see the road, in the expectation that he would be pleased with his new toy.

New Railroad Bridge in Sweden.—The highest bridge in Sweden is rapidly approaching completion. It is being built by the Motala Engineering Company, for the Swedish State Railroads, across the Angerman River. It was to have been ready by August 1, but unforeseen circumstances will delay its completion. The bridge has five arches and a total length of 825 ft., the central arch, which at low water spans the whole of the river, being 225 ft. long. The bridge is supported by four iron piers, of which those on each side of the river are 100 ft. high and rest on huge granite foundations. In these granite pillars are holes for placing dynamite, in case it should be necessary during a war to blow up the bridge. The stone work is already completed, and also the extensive scaffolding, which, however, does not comprise the distance between the two central piers, as the bridge will have to be built in a similar manner to that practised at the Forth Bridge. The bridge has been constructed by Mr. O. Nystrons of the Motala Engineering Company, and the total cost is likely to amount to about $117,000.

Railroads in Sumatra.—Under the direction of the Dutch Government surveys have been made for a railroad to run from the Port of Padang in Sumatra to Ombilien, where there are known to exist extensive deposits of coal of very good quality. These have not been developed to any extent owing to lack of transportation. The distance between the two points is 78 kilos. in a straight line, but between them is a lofty mountain chain which must be surmounted by the railroad, and which will render necessary a line about 145 kilos. in length. After studying a number of proposed routes, the plan adopted by the engineers is to build a road with moderate grades over the plain at the foot of the mountain to a point 56 kilos. from Padang. From that point there will be a line of 26 kilos. in length over the mountain with grades varying from 4 to 7 per cent., and on this section it is proposed to use the Riggenbach rack-rail system. After passing the mountain another section 63 kilos. in length will reach the coal basin; this will have only moderate grades, and will be worked by ordinary locomotives. The plans have been submitted to the Government and approved, and the construction will very soon be begun.

Railroads in Ceylon.—There are 182½ miles of railroad in operation in Ceylon, and all are of 5 ft. 6-in. gauge—viz., Colombo to Kandy, 74½ miles; Peradeniya to Nanuoya, 58¼ miles; Colombo to Kalutara, 27¾ miles; Wharf and Breakwater branch, 4½ miles; Peradeniya to Matale, 17½ miles; total, 182½ miles.

The total profit earned on all the railroad lines at present in operation is about 3 per cent. on the invested capital, which, it is to be feared, is not likely to be appreciably increased so long as the present expensive system is adhered to. Briefly stated, the railroads of this country have proved a positive incubus to the island; excepting, perhaps, the line to Kandy, beyond which place the system never ought to have been extended.

The total cost of the 182½ miles in operation was, exclusive of interest, $16,166,132 in gold.

At present there is no railroad construction in progress, but the following lines have been surveyed—viz.: Kandy to Badulla, 3-ft. 6-in. gauge, 62½ miles, cost not estimated; Nanuoya to Haputale, 5-ft. 6-in. gauge, 26 miles, $3,013,000; Mahara to Chilaw, 5-ft. 6-in. gauge, 40 miles, $1,150 000; Mahara to Chilaw, 3-ft. 3⅜-in. gauge, 40 miles, including to Colombo, $1.200,000; Kalutara to Bentota, 5-ft. 6 in. gauge, 9 miles, no published particulars; Mahara to Jaffna, 183 miles, no published particulars; Mattakuliya to Colombo (tramway), 4½ miles, $271,000.

Proposed Railroads in Asia Minor.—The principal conditions promulgated by the Imperial Administration of Public Works, upon which concessions will be granted for the proposed railroads in Asia Minor, are given below:

The duration of the concession shall be 99 years.

The grantees will be authorized to form a joint company, provided that the company shall be Ottoman and subject to the jurisdiction of Ottoman courts in all its operations.

All public lands necessary for the construction of the road will be ceded gratuitously, land and property belonging to private owners to be expropriated by the grantees or the company.

All supplies necessary for the first establishment of the line shall be exempt from the payment of customs duties.

The contract for its concession and the bonds and obligations of the company shall be exempt from stamp duties.

For the purpose of securing the necessary sums to make up the amount of 15,000 francs gross receipts per kilometer of road built and operated, the following plan will be adopted :

Securities are to be given by the tithe-farmers for the full value of the tithes, and are to be registered in the name of the treasuries of the administration of the public debt in the said several sandjaks. The full amount of the value of said tithes to be at once deposited in said treasuries, and the amounts which the Imperial Government promises and engages itself to pay to make up the amount of gross annual receipts, as above indicated, to be levied on the said value of the tithes, the balance to be remitted to the treasury.

The line now in operation between Haidar-Pacha and Ismidt (95 kilometers), of which the actual receipts are about 10,000 francs, and the works already constructed beyond Ismidt, shall be ceded to the company upon payment of an adequate amount.

Russian Petroleum Trade.—The report of Mr. James C. Chambers, United States Consular Agent at Batoum, Russia, to the State Department, gives elaborate statistics of the shipments of petroleum for two years past, which are summed up as follows, the figures given being for gallons :

	1887.	1886.
From Batoum (Black Sea):		
To Russian points	9,764,050	13,523,330
To foreign countries	67,969,935	54,236,320
Total	77,733,985	67,759,650
From Baku (Caspian Sea):		
To Russian points	310,292,715	265,677,895
To foreign countries	1,789,930	1,305,117
Total	312,082,645	266,983,012
Total of all shipments	389,816,630	334,742,662

The exports from Baku last year were all to Persia ; of those from Batoum about 80 per cent. were to European countries, including Turkey ; 13½ per cent. to Asiatic countries, and 6½ per cent. to African points.

Mr. Chambers says : "The prospects of the Batoum petroleum exporters for 1888 were never brighter, with greatly increased railroad transportation, declining prices at Baku, a steady downward tendency in the value of Russian paper money, and high and advancing prices in the markets of the world. If they do not reap a rich harvest this year, they will have lost a golden opportunity, such as is rarely seen in any business. It is expected here that the Batoum exports this year will be over 150,000,000 gallons, almost double those of 1887, but I do not believe it is possible for them to exceed 120,000,000 gallons. A very good beginning has been made, however, as the January shipments were over 10,000,000 gallons, and the steamer charters for cases January, February, and March, loading for India alone, are nearly 6,000,000 gallons."

The New Brooklyn Dry Dock.—One of the works of greatest magnitude at present under way at the Brooklyn Navy Yard is the digging of the new dry dock.

This dock is one of two contracted for by J. E. Simpson & Company, of New York. The other is being built at the Norfolk Navy Yard, and both together were to be finished for somewhat less than $1,100,000, with a limit of two years in which to complete the work. The material used is spruce, oak, and yellow pine, which is brought from Georgia and the Carolinas, and of which almost the entire dock is to be built, the bottom being concrete over the head of piles driven in as close together as they can be forced.

The length of the Brooklyn dock is 500 ft., extreme width 130 ft. and 4 in., and the depth 32 ft. 8 in.

The steam digger at first employed was found to be not suited to the soil, and the machine was so undermined by its own efforts as to render it practically valueless. A digger of the "clam-shell" type is now employed, and the work has progressed fairly well, although much more slowly than was expected at the start. The fine, sandy soil found at the depth at present reached, as well as the numberless springs of fresh water struck in almost every part of the dock, render digging very slow and unsatisfactory. Large centrifugal pumps are constantly at work freeing the dock of this water, and even then the men at work are frequently up to their knees in the soft, slimy ooze.

To prevent the water filtering in from the Wallabout at a point which will eventually be the mouth of the dock, double-sheet piling is driven, and the intermediate space is filled in with clay. This renders it fairly water-tight, and aids greatly in expediting the work. The caisson, as the boat-shaped gate is called, which closes up the mouth of the dock when finished, is to be made of steel, and has been contracted for by Messrs. Bigelow & Co., of Newburg, N. Y., and is of a pattern that has frequently proved extremely efficacious.

The Centennial of the Marine Engine.—At the recent meeting of the Institution of Naval Architects held in Glasgow, Professor H. Dyer read a paper on The First Century of the Marine Engine," in which he called attention to the fact that the present year is the hundredth anniversary of steam navigation, Mr. Miller having made his first experiment in Dalswinton water in 1788. The following abstract of the paper is taken from *Engineering* :

"The paper commences with the Dalswinton experiment of the three pioneers, Miller, Taylor, and Symington, and then goes on to speak of the *Charlotte Dundas*, designed by Symington in 1801, and tried on the Forth & Clyde Canal in 1802 ; this being described as the first practical steamboat. The attempts of John Fitch, of Connecticut, extending from 1787 to 1798, are touched upon, but all his attempts are described as unfortunate. Robert Fulton's steamer, tried on the Seine in 1803, is mentioned ; his further work in America being also chronicled. John Stevens, of Hoboken, and his son, Robert L. Stevens, also find a place in the record. Henry Bell, of Helensburgh, with the *Comet*, brings the history back to the Clyde District, and John Wood's *Elizabeth*, built for Thomson, is next dealt with. In a foot-note the Author refers to the contribution of Mr. Miller to the *Transactions* of the Institution of Engineers & Shipbuilders of Scotland, vol. xxiv., page 49 ; to Sandham, "On the History of Paddle-Wheel Steam Navigation," in the *Proceedings* of the Institution of Mechanical Engineers, 1885, page 121 ; and also to a handbook, now apparently passing through the press, for the collection of marine models at South Kensington, by Mr. G. Holmes, the secretary of the Institution of Naval Architects. The names of Wood, Steel, Scott, Denny, Caird, and the Napiers are also mentioned, and reference is made to such vessels as the *Rob Roy*, *Robert Bruce*, *Superb*, *Eclipse*, and *James Watt*. The *Savannah*, which made her voyage in 1819, opens the epoch of Atlantic steam navigation, although this ship crossed the Northern Ocean partly under sail, and it was not until 1838, just 50 years ago, that Transatlantic steam navigation became a commercial fact, when the *Sirius* and *Great Western* crossed to America. This brings us to the establishment of the great Atlantic steam lines and the Peninsular & Oriental Company, since which time the progress of events in this connection has been indeed one of the most stupendous facts in this century of engineering marvels. We need not sketch the development of the marine engine through its various stages from those early low-pressure days to the present epoch of steam at 180 lbs., and triple or quadruple engines fitted in such floating mammoths of speed and power as the *City of New York* just starting on her maiden voyage, or the Inman liners *Majestic* and her sister ship now building at the great Belfast shipyard."

English Fast Trains.—On August 6, the first day of the great 400-mile race between two of the biggest English companies, the "Flying Scotchman" was beaten by the "West Coast Flyer." The faster train of the two traversed the greater part of the distance at a speed of a mile a minute.

Competition between the Great Northern and the London & Northwestern companies began to grow lively a year ago when the former, by adding third-class compartments to its Edinburgh limited express, took away the third-class passengers which the Northwestern had hitherto carried on trains going at a somewhat slower speed. Since that time the contest for Edinburgh travel has been active.

As the "Flying Scotchman" on the old nine-hour schedule was the fastest train in the world, the interest taken in the race between the two trains, when both were sent through in eight hours, was naturally great in railway circles and everywhere else.

The two trains pulled out at the same moment, the "Scotchman" from King's Cross Station and the "West Coast" from Euston Station, London. The engine of the "West Coast" had a single pair of driving-wheels 7 ft. 6 in. in diameter, and weighed 27 tons. It burned 24 lbs. of coal per mile during the run. The tender, loaded, weighed 25 tons. Behind it were four coaches filled with passengers, making a weight of 20 tons each, or 80 tons in all.

The entire distance covered by the "West Coast" was 400 miles, and the actual time, excluding stops, was 7 hours and 25 minutes, an average of $53\frac{83}{89}$ miles per hour. This has never been approached before on an English railroad for so long a run. The fastest continuous record in England hitherto was that of the special train which took the Prince of Wales from Liverpool to London, 200 miles, in 3 hours and 59 minutes, an average slightly over 57 miles.

The "Flying Scotchman" ran into Waverly Station on time, but had been beaten not only 7 minutes in time, but 8 miles in distance.

Some details of this initial run may be of interest. From Euston Station to Tring, 31½ miles, generally up grade, the steepest portion being 1 in 70, occupied 40 minutes, and 15 miles, generally down grade from Tring to Bletchley, took only 12½ minutes, the average speed being 72 miles per hour. The distance from London to Tamworth, 110 miles, was made in exactly 120 minutes, while the 48 miles from Tamworth to Crewe took 58 minutes, making the run of 158 miles from London to Crewe without a stop occupy 178 minutes. The second run without a stop was made from Crewe (where the engine was changed) to Preston, 51 miles, and this was done in exactly 51 minutes. A stop of 20 minutes was made at Preston, and on leaving that station there was one run of 88½ miles without a stop. At Carlisle the engines were changed; the best time made on this section was 31 miles from Shap to Carlisle in 31 minutes, the slowest being the 5½ miles up Shap grade, which took 8½ minutes. The 101 miles from Carlisle to Edinburgh was made in 104 minutes, this distance including the Beattock grade of 10 miles long on an incline of 1 in 80, where the speed was reduced to 44½ miles per hour.

This speed, although much higher than any made regularly in this country, was exceeded on the West Shore road some years ago, when the 425 miles from Buffalo to Weehawken was made at an average speed of 54 miles an hour.

A Torpedo-Boat at Sea.—A correspondent of the London *Standard* gives an account of the voyage from Portland to Berehaven of the torpedo gunboat *Sandfly*. This vessel and her sister boats, it may be stated, are supposed to combine seaworthiness and great speed with vast power of destruction. She is only 8 ft. deep, 23 ft. beam, 200 ft. long, and 450 tons burden. She is rated as a 19-knot boat, and capable of steaming 3,000 miles and more at 10 knots without coaling. Her fighting capacity lies in a 4-in. breech-loading gun, six machine-guns, and four torpedo-tubes. The correspondent says:

"Rams, torpedoes, and machine-guns have lost their terror for the officers of the *Sandfly*, all because she has steamed from England to Ireland in a light breeze and easy seas without going to the bottom with all on board. Three sister boats are taking part in these maneuvers, whose crews may yet be alive to tell of what they have passed through; but, lest they all have shared the fate of the *Sandfly*—by no means an extraordinary hypothesis—let me record something about the capacity of this species of craft to inflict torture upon the servants of the Queen, too plucky to shirk the work and too well trained to complain. Whatever may be the qualities of the *Sandfly* in smooth waters, the experience of her officers on the run over illustrates her value for such purposes as she is now put to. From their statements it seems that in the light weather we had all the way from Portland, while the *Hercules* moved with the least possible motion, the *Sandfly* pitched and rolled so violently that the pendulum intended to register the heeling of the vessel proved useless. It registers only 30 degrees on either side, and the *Sandfly* rolled nearly 45, the pendulum striking from side to side. This violence of motion succeeded in knocking the poor surgeon from his chair, and pitching him about in the saloon, until he gave up the struggle with several injuries to the ribs. The ship's company to a man were sick as men never were before. One man finally vomited blood, and the best of them had barely the heart left to stand at their posts, seamen and officers alternating at the lee rail in misery. On the bridge, which is as high as the funnels, the seas dashed up as they do against a cliff, lashing the salt wash into the eyes of those on watch, until cayenne pepper could not have made them smart more. In fact, one man has his eyes bandaged. Forward of this bridge no man can go, for it is as freely under water as the bows of a cayak; and the 4-in. breech-loader that stands there might as well be a champagne-bottle, for any harm it could do an enemy while the vessel is under way. This was most conclusively shown on the journey hither, for the *Warspite* was chased and overhauled by the *Amphion*, of the other fleet, and would surely have been sent to the bottom had actual war existed, for the *Amphion* steamed easily her 15 knots high out of water, while the *Sandfly* could make but 6 knots on the waves, and then rolled and pitched, so that fighting of any kind was totally out of the question. That she can neither make speed nor fight at sea is evident, and what is worse, it is, in the mind of her officers, an even chance whether on any open sea distance she would reach her destination. This short run has so battered her that ever since we have been here she has been undergoing repairs. Her machinery has all the intricacy of clockwork, with much of its fragility. The slightest imperfection anywhere disables her, and not one on board was sanguine enough to think she could float long unless she could keep her head to the sea. Her deck is so close to the water that you can sit and dip your toes in the water over the side, as was the case in the original monitors of the American Navy, but, unlike those vessels, she has bulwarks that hold the water when it rushes over the side, and so destroy the ship's chance of freeing herself rapidly. So low is the vesel, so quick her rolling, and so high her bulwarks, that it would require but a few green seas in succession on board to swamp her effectively. What the boat can do in smooth water is no doubt great, but as a war vessel for general use she has proved a complete failure."

Edison's Phonograph.—Recently a letter appeared in the London *Mail* from Colonel Gouraud, Mr. Edison's agent in England, describing the arrival of the new phonograph which the great inventor has for some time past been engaged in completing. It will be remembered that the first phonograph which was contrived by Mr. Edison many years ago was not a success. It contained a metal cylinder, over which was stretched a smooth sheet of tinfoil, and which could be made to revolve by turning a handle. The sounds were received by a mica diaphragm, from the center of which projected a needle or style, with its free extremity resting upon the tinfoil. Sound waves impinging upon the diaphragm produced vibrations, which were communicated to the style, and caused it to make indentations in the tinfoil; and these indentations, by putting the cylinder into revolution while a forward movement was impressed upon the style, were extended into a continuous spiral line. In order to reproduce sounds, the process was reversed, the point of the style being brought back to the commencement of the spiral line which it had traced, and the cylinder being again made to revolve. Then, just as the style had been originally thrown into definite movements by the vibrations of the diaphragm, so the diaphragm in its turn was thrown into definite vibrations by the movements of the style, and the sounds which had in the first instance traced the line were again excited by its agency. The diaphragm was contained within a tube, into the mouth of which it was necessary to speak; and the reproduced voice, although accurate as far as the repetition of words was concerned, was not accurate in the reproduction of tones or other individual characteristics. The words were more or less "bleated," and the original speaker could not in any case be identified with certainty. The tinfoil could not be removed without destroying the trace; so that a given sound could only be reproduced by the instrument which had received it, and only so long as the foil remained undisturbed and uninjured. The phonograph was used in order to illustrate a principle, by popular lecturers on science; but was otherwise scarcely more than an ingenious toy.

Mr. Edison, although his attention was long diverted from the phonograph by the pressure of other demands upon him, appears always to have believed in its perfectibility, and in the wide range of its ultimate applications; and, for the last year, he has devoted himself closely to the subject. In order to attain scientific perfection, it was necessary to replace the tinfoil by some substance which yielded more readily, and more accurately in minute particulars, to the varying pressure of the style, and which yet, either in its original form or after some simple process of hardening, should possess sufficient firmness to guide the style with absolute correctness for the reproduction of sound. It was also necessary to provide for identity of speed in the revolutions of the cylinder, whether this was receiving sound or transmitting it; and to secure the maintenance of this identity of speed in all the instruments which might be manufactured. For purposes of practical utility, it was further necessary to obtain a recording material which would bear transmission from place to place, or transference from one instrument to another, and which would admit of being accurately copied by electrotype or other processes, and, in this way, of being indefinitely multiplied. All these ends have now been completely or approximately attained; and the phonograph has acquired a form in which it promises shortly to be accessible to the public for a great variety of uses. The tracings of the style are received upon a material which is shaped into cylinders, and these cylinders can be slipped on or off the fixed spindle of the machine. They are of such a quality as to record and reproduce with great accuracy; they can be multiplied indefinitely; they can be transmitted from place to place, or transferred from one phonograph to another; and they will repeat for an indefinite number of times the words or other sounds which they have received. The words and messages mentioned by Colonel Gouraud, for example, were spoken in the first place to an instrument in Mr. Edison's laboratory, the cylinders which received them were removed, packed up, sent across the Atlantic, and finally placed upon another instrument at Norwood. As soon as this second instrument is set in motion, the words are repeated in voices which appear to be perfectly natural.

Like all other great contrivances, it may have its evil or dangerous applications; but there can be no doubt that these will be enormously overbalanced by its utility, and, even if they were not, it would be impossible to withhold the tribute of admiration which is justly due to the genius and the industry of the inventor.